Water Resources Report Number 69

MISSOURI DROUGHT PLAN

revised by

Water Resources Program

2002

Integrity and excellence in all we do

MISSOURI DEPARTMENT OF NATURAL RESOURCES
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Library of Congress Catalog Card Number: 2002104165
Missouri Classification Number: MO/NR Ge9:69

Missouri Department of Natural Resources' Geological Survey and Resource Assessment Division, 2002, ***Missouri Drought Plan,*** Missouri Department of Natural Resources' Geological Survey and Resource Assessment Division, 71 p., 20 illustrations, 13 appendices.

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PREFACE

Beginning in July 1999 and continuing through the summer of 2000 many parts of Missouri experienced drought conditions. Especially hard hit were agriculture and water supply reservoirs in north central and northwestern Missouri. Not only was this a "lack of precipitation drought" but it was compounded by marginal water reserves in several community reservoirs that supplied drinking water. In May 2000, Governor Carnahan asked me to activate the Drought Assessment Committee (DAC) as called for under the terms of the *Missouri Drought Response Plan*. Throughout the summer staff coordinated the efforts of the 14 state and federal agencies that comprise the DAC. They worked together to alleviate the myriad of problems associated with the drought. This action marked a milestone, unfortunate as it was, that the *Missouri Drought Response Plan* was activated for the first time since its development in 1995. Fortunately, however, Missouri has a drought plan with coordination and communication mechanisms in place to respond to just such an emergency.

The DAC quickly moved into action, forming impact teams to address the drought affected areas and water uses. Through the DAC and its drought impact teams we were able to improve rainfall reporting, stream flow measurements and groundwater level monitoring to near real time. We undertook reservoir operations modeling (RESOP) and bathymetric studies to help local communities determine just how much water was available in their reservoirs, streams and wells for public drinking water supply. The DAC also coordinated the release of emergency conservation reserve lands and emergency water supply alternatives for livestock and agriculture needs. One of the greatest successes, and conversely an area where we need to focus our efforts further, is the coordination and communication among federal, state and local governments to move quickly and decisively to plan and respond to drought emergencies.

Without this plan, the effects of the last drought on Missouri's citizens, communities and businesses would have been worse. This revised 2001 *Missouri Drought Plan* reflects the lessons that we learned and the insights we gained in responding to the drought of 2000. While it is my hope that we never again have to activate the *Missouri Drought Plan* I know that is unrealistic. Of all the functions that government does, probably the most important is responding quickly and efficiently to the needs of our citizens in time of crisis. That is what the *Missouri Drought Plan* does.

Stephen M. Mahfood, Director
Missouri Department of Natural Resources

FOREWORD

This publication is presented as an aid, under the State Water Plan, to state, federal and local government officials, commercial, industrial, and private water users, and to private and public suppliers to plan for and respond to drought events in Missouri.

The original *Missouri Drought Response Plan* was published in 1995. It was authored by Don E. Miller with assistance from Charles Hays. Miller, now retired, was the Groundwater Section Manager, of the Missouri Department of Natural Resources, Division of Geology and Land Survey (DGLS), Water Resources Program. The name of this division was changed to Geological Survey and Resource Assessment Division (GSRAD) in 2001. Charles Hays is the Chief Planner for the State Water Plan, also in the Water Resources Program.

As a result of the drought of 1999 - 2000, extensive revisions to the plan were made. These revisions were requested by the Drought Advisory Committee and were based on experience gained during that drought. The following staff from the Water Resources Program prepared this revised edition: Charles Hays, Chief State Water Planner - Water Resources Planning, Bruce Netzler, Section Chief - Water Resources Planning, and Steve McIntosh, Director - Water Resources Program. Assistance and recommendations for this 2001 *Missouri Drought Plan* were provided by numerous state and federal agencies and other sources.

The program thanks Steve McIntosh, Water Resources Program Director, for his comments, review of the many drafts and for his direction of the plan revision. We would also like to thank Mimi Garstang, Director and State Geologist, Geological Survey and Resource Assessment Division (GSRAD), Mike Wells, Deputy Director, GSRAD, Jeff Staake, Deputy Director, Missouri Department of Natural Resources, and Joe Engeln, Assistant to the Director, Science and Technology, for their comments and review of this plan. Also, written comments to the 1995 Missouri Drought Response Plan were received from, Scott Totten, Director - Water Protection and Soil Conservation Division, Alice Geller, Department Director's Office, John Madras, Water Pollution Control Program, Deanna Cash, Public Drinking Water Program, Adnan Akyuz, Missouri State Climatologist, Brenda Heidbreder, State Emergency Management Agency, and Robert Steiert, U.S. Environmental Protection Agency (Region 7) and have helped to shape this revised plan. We would also like to thank Terry Frueh, Water Resources Program, for generating maps and Susan Dunn, Administration Program for map generation, layout and publication coordination.

INTRODUCTION

The primary purpose of the Missouri Drought Plan is to address the need for coordinated response and advanced emergency planning. It complements and supports the State Consolidated Plan and the State Emergency Operations Plan. Disaster response is often reactive. The drought plan outlines proactive strategic and tactical measures designed to better prepare Missouri for drought. It is a drought response plan and does not eliminate the need for long range strategic planning, which would address the bigger issue of drought impact avoidance.

Drought planning is action taken by individual citizens, industry, government, and others in advance of water shortages to mitigate some of the impacts and conflicts associated with its occurrence. Drought response, conversely, is composed of actions taken during a drought to lessen its impacts on people, the environment and the economy.

The initial Drought Response Plan published in 1995, was the result of Midwest drought data collection and evaluation work done by the Department of Natural Resources' Geological Survey and Resource Assessment Division, Water Resources Program staff. Ideas were "brainstormed" over a period of several months to formulate a drought plan that fits Missouri. It was modeled, in part, on the Kentucky Drought Response Plan.

The State Water Resources Plan (section 640.415 RSMo), which is a provision of the Water Resources Law enacted by the Missouri Legislature in 1989, requires the Department of Natural Resources to ensure that the quality and quantity of Missouri's water resources are maintained at the highest possible level to support present and future beneficial uses.

The provision was established to provide for the development, maintenance and periodic updating of a long-range, comprehensive statewide plan for the use of surface and groundwater. It includes existing and future requirements for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs.

The department is responsible for collecting data, making surveys, conducting investigations and providing recommendations concerning the social, economic and environmental water resources needs of the state.

Water quantity, quality and availability affect the well-being of all Missouri citizens. When water quality is good and the supply is plentiful, these two critical factors are often taken for granted. But when good water becomes a scarce commodity and people must compete for the available supply, then the importance of these two factors increases dramatically. Quite often, only a few water users are critically affected but in cases of severe and prolonged drought, everyone may be affected. The Missouri Plan is designed to effectively mitigate any water shortage due to drought conditions.

The 2001 version includes revisions recommended by the Missouri Drought Assessment Committee (DAC) following the drought of 1999 - 2000. During the preparation of this plan, input was solicited from various water management programs within the department, the University of Missouri departments of Agricultural Extension and the college of Agriculture, Food and Natural Resource and from the Missouri departments of: Agriculture, Conservation, Economic Development, Health, and Public Safety.

The Missouri Department of Natural Resources gratefully acknowledges the support and assistance it has received from many individuals and agencies, especially the Drought Assessment Committee.

PROBLEM

Drought, as it affects the citizens of Missouri, is primarily a problem of rural water supplies. Large municipalities, with a few exceptions, have not had major water supply problems to the same degree that small communities have had. Small communities supplied by small surface water structures have experienced some serious difficulties.

Other effects of drought include reduced agricultural crop production, increased costs to supply necessary water to crops and livestock and threats to water quality.

Supply droughts are characterized by a lack of precipitation to replenish and maintain normal seasonal levels of surface and groundwater. Supply droughts are typically acts of nature. A water use drought is typically the result of human actions. Simply stated, more water being used than is available because of increased water use or reduced supply. A water use drought can occur during times of normal precipitation as well as during supply droughts. Dependent upon weather conditions, water supply sources, and water use demands, supply droughts and water use droughts can occur independently or simultaneously.

DROUGHT PLANNING

Drought is usually a regional issue with statewide implications. Preventing water shortages in public water systems should be one of the major goals of drought mitigation. The design and construction of systems for the "drought of record" or some other reliable measure, should be a significant part of any system for drought planning and adverse drought effect avoidance. State regulatory and funding agencies need to be involved at an early stage to do proper planning.

Planning for drought should go beyond simply working to find sources of potable water and getting it to where it is most needed. Planning should also include assessment of the vulnerability of the activities or growth planned within the drought-prone areas. Facilities and activities that consume large amounts of water should not be located in areas that are vulnerable to extreme drought, without a thorough evaluation of their drought susceptibility, and an analysis of impacts on competing users under a drought scenario. Expansions of existing facilities should undergo the same analysis.

Another aspect of drought planning, not to be overlooked, is that drought can be a statewide, regional, or localized problem. The type of response needed depends on the size of the affected area, as will the data needs and the resources that have been committed to solving the problem. Local drought response (Appendix 4) should be implemented at an early stage during any observed decrease in water availability. Implementation of regional and statewide responses will occur as the effects of the drought expand in geographic size or severity.

Planning for drought requires accurate and timely water resource data. Water resource data is collected in Missouri primarily by two agencies: the Missouri Department of Natural Resources and the United States Geological Survey (USGS). The department's Geological Survey and Resource Assessment Division, Water Resources Program has systematically collected groundwater-level data since the mid-1950s. The statewide groundwater-level observation well network was recently updated and expanded to 70 wells, all equipped with electronic water-level recorders that measures and record the depth to water every half-hour. Additionally, each installation contains a low-power transmitter that sends the data to the office every 4 hours using the Geostationary Operational Environmental Satellite (GOES) weather satellite system. The USGS operates approximately 150 surface-water gaging stations throughout Missouri. Many of these gaging stations are also equipped with electronic recorders and GOES transmitters to allow real-time access to the data. Data from both of these systems can be viewed on the same Internet web site http:/missouri.usgs.gov/. Data collection installations such as these allow the effects of drought to be monitored on a real-time basis, and allow more accurate and timely drought forecasting.

Planning for drought also requires accurate and current water use data. Water metering should be improved so that water loss can be detected. Distribution systems should be up-graded as much as is practicable (especially in drought-vulnerable areas) to eliminate water loss. Where water supply wells are used, the utility should keep accurate, monthly records of draw-down so that background information

may be developed to allow for the timely assessment of drought conditions. The Department of Natural Resources in cooperation with the U.S. Geological Survey are developing drought firm yield studies for most drought vulnerable surface water supply reservoirs and sustainable flow estimates for river intakes.

From late 1999 through the first half of the year 2000 most of Missouri was adversely effected by low rainfall amounts. On May 23, 2000 the Governor, at the recommendation of the Director of the Department of Natural Resources, Stephen Mahfood, announced the activation of the Missouri Drought Assessment Committee (DAC). This marked the first time that the DAC had been activated. This Committee, made up of 14 state and federal agencies, was tasked with assessing drought conditions across the state and recommending actions to ease the drought's adverse effects.

Suffering from some of the worst drought conditions in years, the drinking water reservoir levels in many northern Missouri cities were very low. Many local water supplies imposed voluntary or required restrictions on water use. Additional pipelines were also laid to allow water to be drawn from local streams to meet the water demand.

In 2000, the Reservoir Operation Study Computer Program (RESOP), developed by the U.S. Department of Agriculture, was used to evaluate the water supply and demand for Green City, Brookfield, Hamilton, Jamesport, King City, Stansberry and Milan. Many water suppliers located in north Missouri were experiencing severe drinking water supply problems. Different climatic scenarios were examined for the RESOP water balance calculation to provide estimates on future water availability. The RESOP model is used for the planning, design, and evaluating of reservoirs to meet their water supply and demand requirements. Currently, the USGS continues to conduct drinking water reservoir sediment surveys at the request of the Department of Natural Resources. The department plans to use RESOP to perform firm yield studies on all vulnerable public water supply reservoirs.

DEFINING DROUGHT

Initiation and execution of the Missouri Drought Plan relies upon an accurate assessment of existing drought conditions. A fundamental element of planning is the establishment of criteria that, if properly considered, can be used to gauge drought severity. In the following section, several drought severity indicators are briefly discussed. No single index or measurement provides an accurate assessment of drought conditions. However, when several are used in combination and supplemented with information on stream, reservoir and groundwater levels, an accurate estimation of the drought conditions can be attained. The following is only a partial list, new drought indices and indicators are being created as technology develops.

MONITORING DROUGHT:

Drought Indices

The most commonly used drought severity indices are the Palmer Drought Severity Index (PDSI), and the Crop Moisture Index. Each of these indices is published jointly on a weekly basis by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture (USDA). Other drought indices include Percent of Normal Precipitation, Standardized Precipitation Index (SPI), Reclamation Drought Index, and Precipitation Deciles. These are the standard drought indices recognized by National Drought Mitigation Center.

The Palmer Index is more widely used than any other single indicator; the Missouri Drought Response System joins a number of states in placing emphasis on the PDSI in determinations of drought severity. The PDSI provides a standardized means of depicting drought severity throughout the continental United States. It measures the departure of water supply (in terms of precipitation and stored soil moisture) from demand (the amount of water required to recharge soil and keep rivers, lakes and reservoirs at normal levels). By relating these figures to the previous regional index, a continuous "stream" of data is created reflecting long-term wet or dry tendencies. The PDSI is primarily a long-term drought condition indicator.

Missouri has six regions that display similar climatic characteristics. For each region, drought severity can be determined according to the following values:

Above	>	4.0	Extreme Moist Spell
3.0	to	3.9	Very Moist Spell
2.0	to	2.9	Unusual Moist Spell
1.0	to	1.9	Moist Spell
0.5	to	0.9	Incipient Moist Spell
0.4	to	-0.4	Near Normal Conditions
-0.5	to	-0.9	Incipient Drought
-1.0	to	-1.9	Mild Drought
-2.0	to	-2.9	Moderate Drought
-3.0	to	-3.9	Severe Drought
Below	<	-4.0	Extreme Drought

The Crop Moisture Index (CMI) uses meteorological approaches to monitor week-to-week crop conditions. It is a Palmer Index derivative and reflects moisture supply in the short term across major crop-producing regions. As such, it is not intended to assess long-term droughts. It is based on the mean temperature and total precipitation for each week within a Climate Division, as well as the CMI value from the previous week. The CMI responds rapidly to changing conditions, it is weighted by location and time so that maps, which commonly display the weekly CMI across the U.S., can be used to compare moisture conditions at different locations. NOAA and USDA prepare weekly maps for the continental U.S.

Other indicators of drought severity less conceptual in nature than the Palmer Index do exist, however, they are typically used to support the conclusions of the Palmer Index. In a practical sense, they often serve as the de facto "triggers" of any

drought response effort. These include: water demand versus supplies available, reductions in stream flow, declining reservoir levels, precipitation deficits, falling water levels in wells and soil moisture supply.

Percent of Normal Precipitation is one of the simplest measurements of rainfall for a specific location. It is calculated by dividing the actual precipitation amount by a 30-year mean precipitation amount. Time scales are generally stated in months or year. The Percent of Normal is effective for comparing a single region or season in easily understood terms.

The Standardized Precipitation Index (SPI) is an index designed to quantify the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of the different water resources. The SPI calculation for any location is based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater than median precipitation, while negative values indicate less than median precipitation. Because SPI is normalized, wetter and drier climates can be represented in the same way, and wet periods can also be monitored by the SPI.

The Reclamation Drought Index (RDI), is calculated at the river basin level and used in determining drought severity and duration, and for predicting the onset and end of periods of drought. A key aspect of PDI is that it incorporates temperature as well as precipitation, snowpack, streamflow and reservoir levels as input.

Precipitation Deciles groups monthly precipitation occurrences into deciles, arranging monthly precipitation data into deciles to avoid some of the weaknesses within the Percent of Normal method. Deciles provide a statistically accurate measurement of precipitation but requires long time frame climatic data records.

In addition to the drought indices previously identified above, the United States Department of Agriculture, Forest Service (USDAFS) operates a Wildland Fire Assessment System (WFAS). The USDAFS generates maps, on a daily basis, of fire weather and fire danger components of the National Fire Danger Rating System (NFDRS). Mid-afternoon observations are taken at weather stations, which are reported to the Weather Information Management System and are processed by the NFDRS and are then reported to the public the following day. WFAS/NFDRS products include Fire Danger Maps which take into account current and antecedent weather (including precipitation/lack of precipitation, humidity, and lightning), fuel types and the state of both live fuel moisture (or greenness conditions), and dead fuel moisture. The Keetch-Byram Drought Index is a soil/duff drought index that ranges from 0 (no drought) to 800 (extreme drought) and is based on a soil capacity of 8 inches of water. Factors used in the determination of the Keetch-Byram Index include maximum daily temperature, daily precipitation, antecedent precipitation, and annual precipitation.

Drought Indicators

The National Drought Mitigation Center (NDMC) in Lincoln, Nebraska (http://enso.unl.edu/ndmc/) publishes and continually updates drought and drought related products, including the Drought Monitor. The Drought Monitor is a weekly updated comprehensive drought monitoring indicator which coordinates the efforts of USDA, NOAA/CPC, and the NDMC. Unlike the aforementioned indices, which monitor one or a very few variables, the Drought Monitor is a more comprehensive drought indicator which incorporates various indices into a single consensus map depiction of drought occurring within an area.

In addition to the NOAA/USDA-produced indices/indicators, water management agencies in Missouri have access to the Missouri Crop and Weather Report, produced by the Missouri Agricultural Statistics Service. These reports provide detailed statistical information on weather conditions, crop conditions, topsoil moisture supply and subsoil moisture supply for nine Missouri agricultural statistics districts and the state average. Weekly and monthly precipitation data by county are also provided.

Other drought indicators, tools and sources that can be used to produce more local level information include the groundwater measurement network and remote sensing data. The Missouri State Climatologist / Missouri Climate Center, located at the University of Missouri-Columbia (http://www.missouri.edu/~moclimat), has various useful drought related products, including internet linked access to automated weather network, U.S. drought assessment products, storm events in Missouri, interactive weather information, weather related impacts on Missouri agriculture, and research activities and findings.

CATEGORIES OF DROUGHT

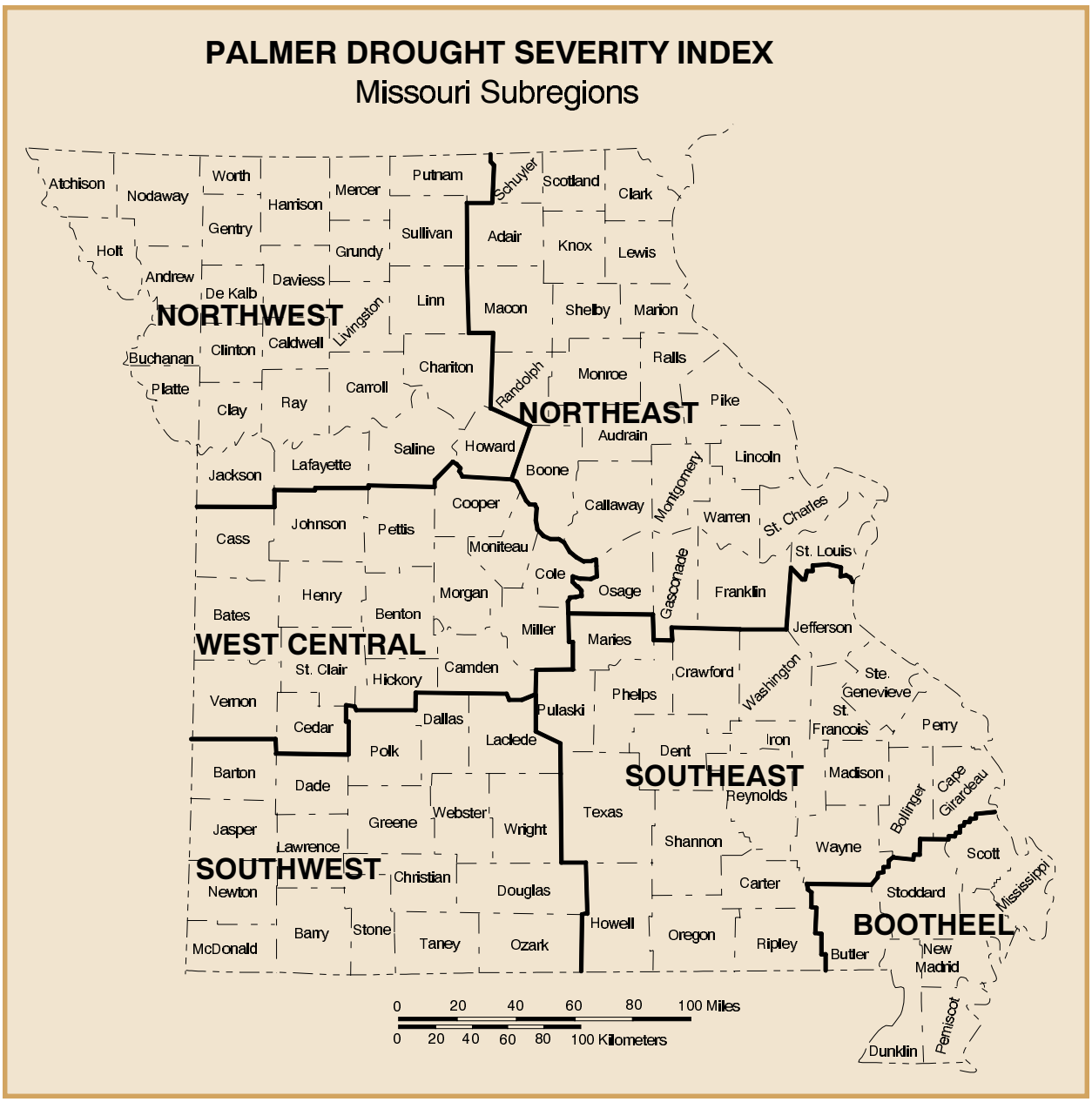
Current drought literature commonly distinguishes between five "categories" of drought, all of which define drought in simplified terms:

1. Agricultural drought, defined by soil moisture deficiencies,
2. Hydrological drought, defined by declining surface and groundwater supplies
3. Meteorological drought, defined by precipitation deficiencies,
4. Hydrological drought and land use, defined as a meteorological drought in one area that has hydrological impacts in another area, i.e. a drought in the Rocky Mountains may be significant in Missouri because the Missouri River is in part dependant upon upstream precipitation and snow pack, and
5. Socioeconomic drought, defined as drought impacting supply and demand of some economic commodity

For the purposes of drought response planning, all five categories can be regarded as equivalent, since each one relates the occurrence of drought to water shortfalls in some component of the hydrologic cycle. At first glance, this association appears to be self-evident; however, it serves to point out a potential pitfall in the use of drought indicators. No single drought indicator can be reliably used to

predict the onset of drought. Regional indicators such as the Palmer Index are limited in that they respond slowly to deteriorating conditions (thus misrepresenting drought severity). They sometimes make unrealistic assumptions using insufficient data. On the other hand, surface and groundwater measurements are "snapshots" of local conditions and do not consider the full hydrologic cycle.

For example, if precipitation levels were to fall below normal for an extended period of time, the conditions for meteorological drought would be satisfied. However, a precipitation deficit does not necessarily mean there is a water-supply shortage. Someone approaching drought assessment from the hydrological or agricultural drought perspective might be only peripherally concerned by the lack of rain, and respond only when streamflow or soil moisture levels have fallen significantly.



Consequently, the use of a variety of drought indicators is essential to any effective assessment of drought conditions. While a water supply may be experiencing significantly reduced water levels without necessarily having other drought indicators significantly present, state drought response actions may not be implemented. Rather, increased use during summer months and increased use due to growth may cause water levels to significantly drop. Water rationing would need to be implemented locally even if other drought indicators are not present. Water levels should be monitored frequently to assess the impact on the aquifer or the surface water level resulting from increased demands and growth.

The Missouri Drought Plan relies upon all the indices to indicate drought severity, and supplements these with streamflow, reservoir-level and groundwater-level measurements. While our inability to make reliable long-term weather forecasts prevents us from accurately predicting the onset or end of drought, responsible use of a combination of the techniques can provide a means by which planners can gauge the severity of drought, and respond to the problem at hand. A drought brought about by water overuse and a supply drought can have the same impact on the water users. They compound the water supply problems when they occur simultaneously.

OVERVIEW OF MISSOURI DROUGHT SUSCEPTIBILITY

Missouri is hydrologically and geologically diverse. The average annual rainfall ranges from about 34 inches in northwest Missouri to about 51 inches in southeast Missouri.

The average annual runoff from precipitation varies from less than 5-inches to more than 20-inches per year.

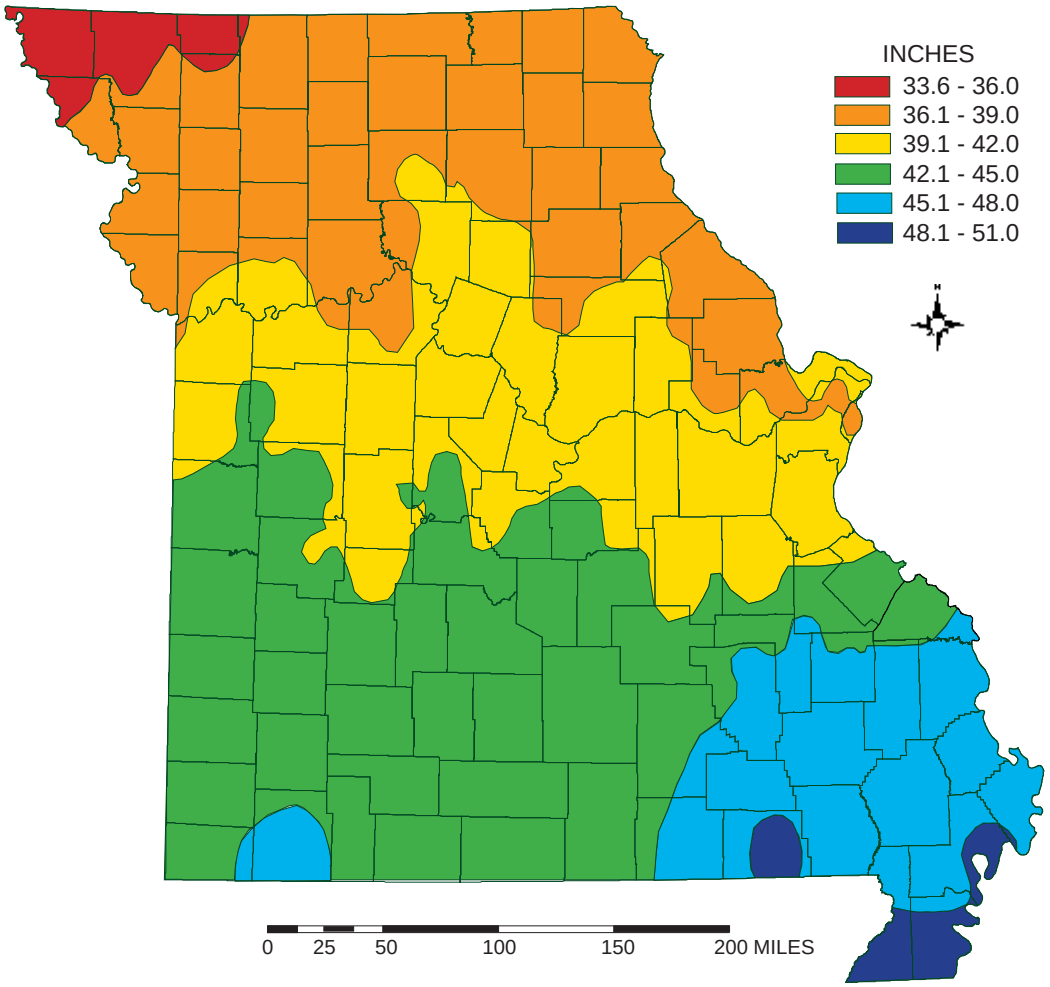
The average annual lake evaporation ranges from less than 36-inches a year in the northeast part of the state to more than 44-inches a year in the southwest part.

Compared to most western states, even the driest areas of Missouri have enviable amounts of rainfall; however, some areas of the state are still water-short in terms of rainfall in relation to needs and uses.

SOUTHERN MISSOURI

Historically, most of the southern half of the state has abundant groundwater resources, making it less susceptible to problems caused by prolonged periods without rain. Even with decreased streamflow or lowered reservoir levels, groundwater is still a viable resource in southern Missouri.

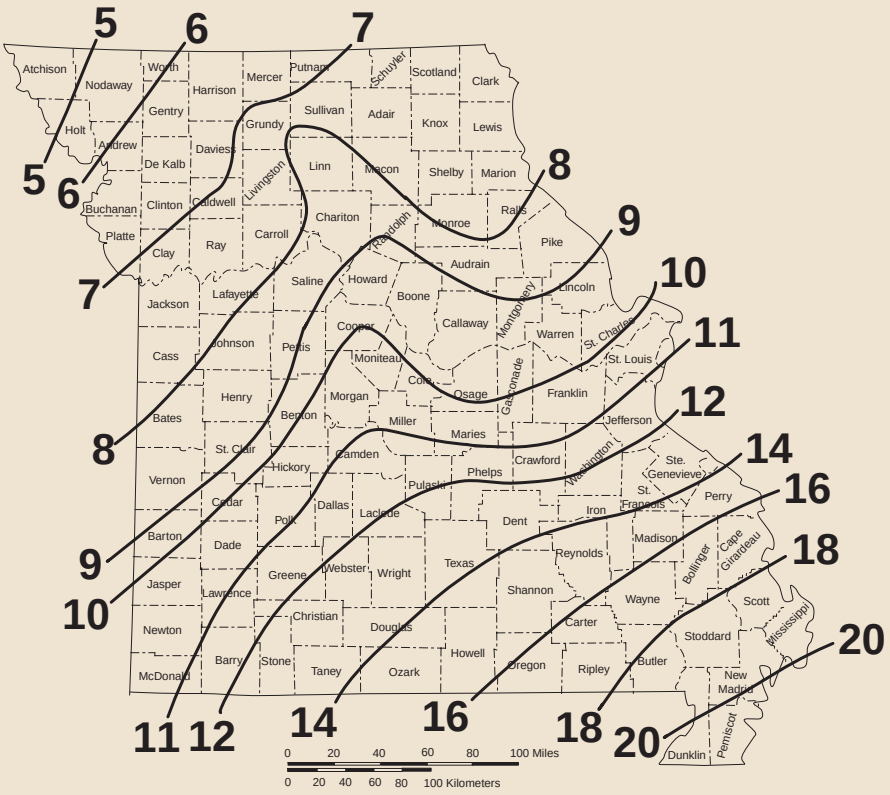
AVERAGE 1971-2000 TOTAL ANNUAL PRECIPITATION



Source: Steve Hu, former Missouri State Clitmatologist

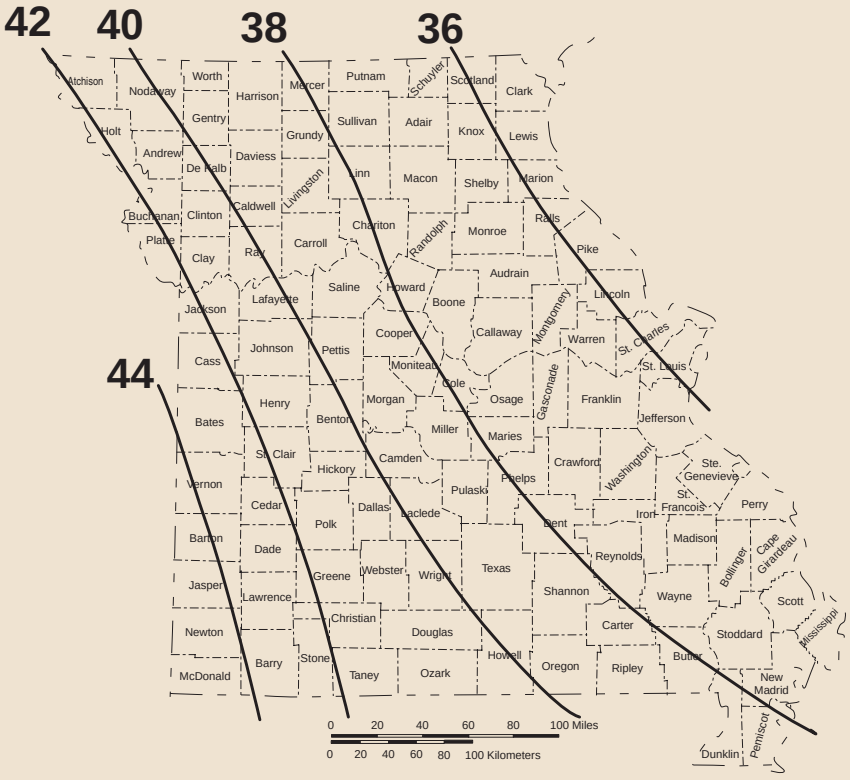
The agricultural needs for water, with the exception of the Bootheel area, are not typically as great in this region as they are in other parts of the state because row-crop farming is not extensive in southern Missouri. The only exception is in the southwestern and southeastern areas where irrigation is used. Although groundwater is an abundant and fresh resource in SW Missouri, seasonal increased use due to tourism and rapid residential and commercial growth in areas is an issue of concern. Wells that have been drilled too closely to each other in the past (present well construction rules address this issue) may impact the water levels in nearby wells if the wells water production increases. The depletion of the aquifer from overuse and/or the aquifer drawdown from closely located wells often requires well pumps to be lowered and sometimes requires wells to be drilled to a greater depth. Also, water systems should frequently evaluate the drawdown and compare it to past drawdowns to determine the current and historical impacts to the aquifer. Population growth in southwestern Missouri has increased water demand in that region. Increased planning efforts are needed to mitigate the effects of future droughts in that area.

AVERAGE ANNUAL RUNOFF



Source: USGS

AVERAGE ANNUAL LAKE EVAPORATION



Source: USGS

NORTHERN AND WEST-CENTRAL MISSOURI

Most of west-central and northern Missouri are underlain by rocks that contain water that is generally too mineralized for most uses. There are some domestic water supplies that get their water from the upper portion of the bedrock but usually the well yield and quality are marginal. The most widely used aquifer in this region is the glacial drift. The glacial drift can yield from less than a gallon of water a minute, to as much as 500 gpm. Average yields are probably less than 5 gpm. During times of drought, domestic wells located on hills and ridges will be affected more than wells located in the valley bottoms. During times of prolonged drought the upland wells may not be adequate for domestic water supply.

Most streams in northern Missouri do not receive appreciable groundwater recharge. During periods of drought, these streams are generally reduced to a series of pools or may become completely dry. Streams and water impoundments are the major sources of water and when a drought is prolonged, these resources are at risk. This may be particularly true where treated wastewater constitutes a significant percentage of the base flow of streams during drought periods.

Agricultural producers in west-central and northern Missouri are usually the first to feel the effects of drought. Row cropping is more extensive in this part of the state and except on the floodplains of major rivers, where alluvial groundwater resources are adequate, irrigation is generally not feasible.

Farm ponds generally supply the water needs of livestock in northern Missouri. These water sources typically become inadequate during prolonged drought.

Prior to any detailed planning and determination of available alternatives, the state should be divided into regions prioritized according to drought susceptibility (see map on page 13).

Region A has minor surface and groundwater supply drought susceptibility. It is a region underlain by saturated sands and gravels (alluvial deposits). Surface and groundwater resources are generally adequate for domestic, municipal, and agricultural needs.

Region B has moderate surface and groundwater supply drought susceptibility. Groundwater resources are adequate to meet domestic and municipal water needs, but due to required well depths, irrigation wells are very expensive. The topography generally is unsuitable for row-crop irrigation.

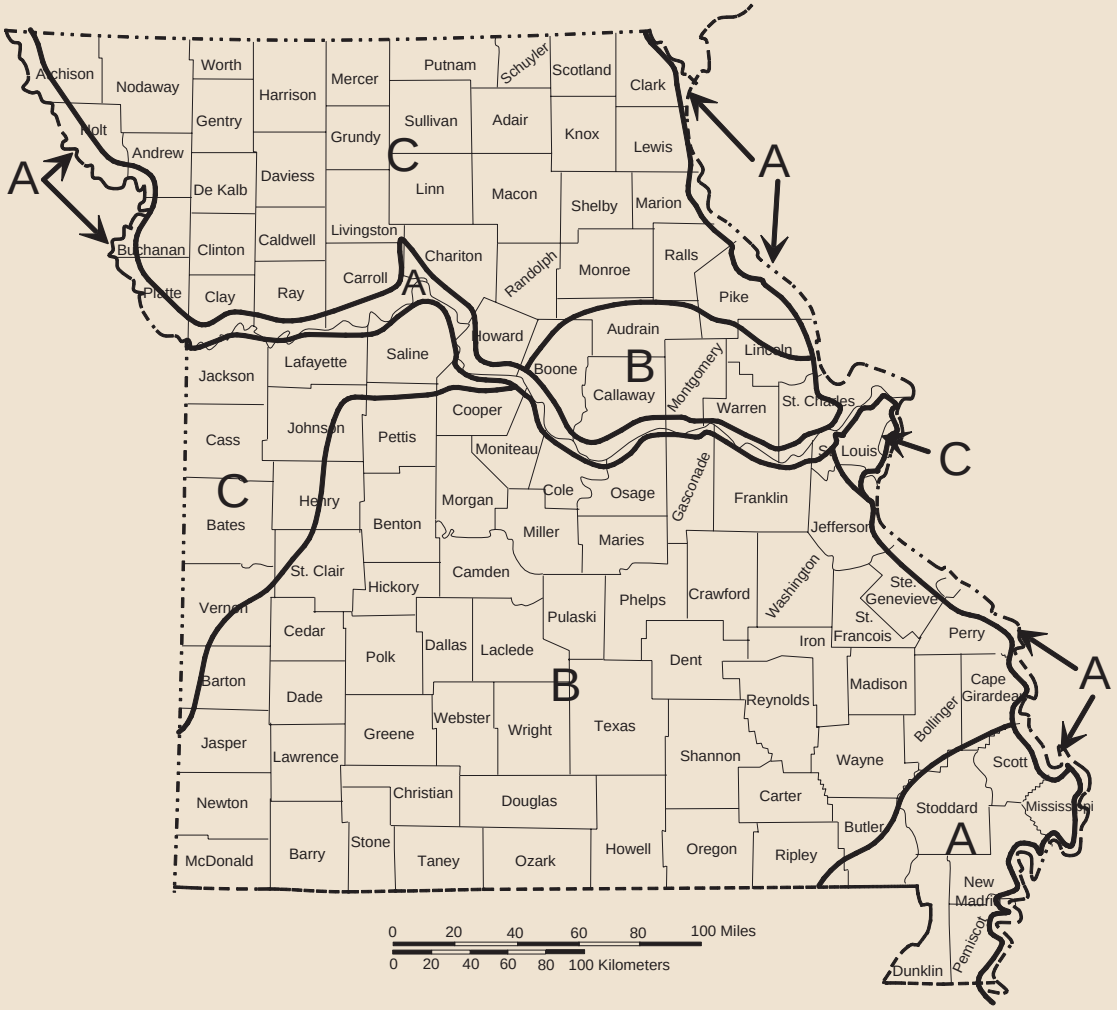
Region C has severe surface and groundwater supply drought vulnerability. Surface water sources usually become inadequate during extended drought. Groundwater resources are naturally of poor quality and typically only supply enough water for domestic needs. Irrigation is generally not feasible. When irrigation is practical, groundwater withdrawal may affect other users. Surface water sources are used to supplement irrigation supplied by groundwater sources.

Since the areas in this region with poor groundwater yield and quality that rely on surface water resources for public water supply are the areas that appear to be the most vulnerable to drought, they should be the focus of drought planning activities. They should be designated Priority Drought Management Areas and be given a high priority relative to drought mitigation and water supply regionalization ac-

tivities. The borders of the management area can be expanded if drought affected areas enlarge. The delineations of these regions also need to be considered from a perspective of:

1) historical drought occurrences in an area/region,
2) actual annual and seasonal rainfall amounts,
3) current and projected water demands and uses within an area,
4) sources of water available for use,
5) water reserves and accessibility to additional water supplies, and
6) current populations and projected population trends that are linked to water use amounts. Specific locations within each of these regions may be more or less susceptible to drought because of local water supplies or use patterns.

DROUGHT SUSCEPTIBILITY



Region A: Slight Susceptibility
Region B: Moderate Susceptibility
Region C: High Susceptibility

CONCEPT OF RESPONSE PLAN OPERATIONS

The Missouri Drought Plan provides for measured responses to worsening effects of drought. It allows flexibility in responding to drought and guides both local and statewide mitigation efforts. The level of drought is generally determined on a county-by-county basis, although more specific recommendations can be made in response to a specific situation.

PHASES OF DROUGHT RESPONSE SYSTEM

Missouri's Drought Response System is divided into four phases:

Phase 1 - Advisory Phase

A. A drought monitoring and assessment system is required to provide enough lead-time for state and local planners to take appropriate action. The department and the Climate and Weather Committee (CWC) will supply water monitoring analysis of anticipated drought consequences to the Drought Assessment Committee based on the assumption that the conditions will continue. The Climate and Weather Committee is a standing sub-committee of the DAC. The Climate and Weather Committee is used as the mechanism for asking the department director to convene the DAC. The CWC is chaired by the departments' Water Resources Program Director and meets as needed.

B. **The Climate and Weather Committee:** The Climate and Weather Committee is responsible for evaluating the precipitation and water supply information from around the state. The committee shall notify the director should conditions warrant activation of the DAC. The committee also makes recommendations to the DAC on the drought status in individual counties in Missouri. Because of the significance of climate and weather, this committee can be both a standing committee and/or an Impact Team at the discretion of the DAC.

Phase 2 - Drought Alert

A. When the **Palmer Drought Index** reads -1.0 to -2.0, and streamflow, reservoir levels and groundwater levels are below normal over a several month period, and/or the CWC determines Phase 2 activities are required using other drought determination methods listed above, then the Governor will be requested

by the department director to make a drought alert declaration for those counties, regions or drought management areas of the state experiencing these conditions.

B. **Drought Assessment Committee (DAC)**: If a Phase 2 - Drought alert is declared by the Governor then the director of the Department of Natural Resources or designee will activate and chair the DAC. A DAC vice-chair will be selected by the committee from among participating DAC members. The DAC will consist of representatives from the following agencies and other agencies designated by the DAC as appropriate. The following list is not all inclusive and additional staff may be solicited to attend DAC meetings and participate in various Impact Teams. The CWC will continue to advise the DAC throughout the drought process.

1. Missouri Department of Natural Resources
   a. Office of the Director
   b. Geological Survey and Resource Assessment Division
   c. Outreach and Assistance Center
   d. Division of State Parks
   e. Air and Land Protection Division
   f. Water Protection and Soil Conservation Division
2. Missouri Department of Agriculture
   a. Office of the Director
   b. Policy and Planning
3. Missouri Department of Public Safety
   a. Office of the Director
   b. State Emergency Management Agency
   c. Adjutant General
   d. Missouri National Guard
   e. Missouri Water Patrol
   f. Air National Guard
4. Missouri Department of Health and Senior Services
   a. Office of the Director
   b. Bureau of Epidemiology
5. Missouri Department of Conservation
   a. Conservation Commission
   b. Planning Division
   c. Engineering Division
   d. Operations Division
6. Missouri Department of Economic Development
   a. Office of the Director
   b. Public Service Commission
   c. Community Development Programs
7. Missouri Department of Social Services
   a. Office of the Director
   b. Division of Family Services
   c. Division of Medical Services
8. University of Missouri-Columbia
   a. Cooperative Extension Service

b. Department of Agriculture
c. College of Engineering
d. State Climatologist

9. U.S. Department of Commerce
   a. National Oceanic and Atmospheric Administration/National Weather Service
10. U.S. Department of Agriculture
    a. Natural Resource Conservation Service
    b. Farm Service Agency
    c. Forest Service
    d. Rural Development Program
11. U.S. Army
    a. Corps of Engineers
    b. Army Reserves
12. U.S. Department of the Interior
    a. Geological Survey, Water Resources Division
    b. Fish and Wildlife Service
13. U.S. Environmental Protection Agency
14. Federal Emergency Management Agency
15. Local Groups and Entities
    a. Cities
    b. Counties
    c. Utility Companies
16. Regional Planning Commissions

C. The **Drought Assessment Committee** shall carry out these and other tasks as assigned:

1. Provide a reporting system format and issue drought status through phases 2-4 of a drought.
2. Review the recommendations of the Climate and Weather Committee (see below) and designate the drought levels for each county in Missouri.
3. Recommend the activation of and coordinate with representatives of Impact Teams (IT)(to be explained below) for the development of additional assessment information and the identification of emergency needs.
4. Make recommendations to the Governor concerning state-level or regional response and recovery.
5. Make recommendations relating to proposed State actions, including the activation of Impact Teams to monitor and review potential impacts on the State's agriculture, economy, environment, and natural resources.
6. Identify resource deficiencies that may aggravate drought effects.
7. Coordinate with the Governor and others as needed to develop drought legislation.
8. Evaluate how the plan is working, from information provided by the Impact Teams and local water shortage teams.
9. Produce drought reports as necessary.

10. Activate ITs and charge each IT with specific responsibilities. Not all teams will be needed in every drought situation. The DAC will appoint a chairperson, a vice chair and the membership of each IT.
11. The DAC will make sure that the county commission in every county that is being affected by drought has available to them a copy of the Missouri Drought Plan to support local efforts to mitigate the effects of drought.
12. Debrief following a drought event and make revisions to Missouri Drought Plan as deemed necessary.

D. **Impact Teams**: The Impact Teams are composed of agency staff who are technical experts. The ITs gather, review and provide specific, detailed reports and analyses. The ITs shall report their findings and recommendations to the DAC. The recommendations, reports and findings from each IT should be reviewed by the DAC and the department for potential addition to the Missouri Drought Plan. Computer and internet technology should be used to the fullest extent possible by all ITs, under the direction of the DAC, especially for public communications and data dissemination for current and prior drought events. It is recommended that appropriate state agencies keep updated listings of locations or sites of important environmental economic or social significance, for timely access and reference by the DAC, ITs, and the public at large. The following are a partial listing of potential IT committees and topics:
    1. Agriculture: livestock, crops, farm ponds, irrigation, and roughage/forage
    2. Natural Resources and Environmental: fish, forests, wildlife, aquifers, rivers and streams, and streamflow
    3. Recreation: tourism and navigation
    4. Water Supplies and Wastewater: public, private, commercial, industrial, utilities
    5. Health: human health, water contamination
    6. Social and Communications: public communications, and demographic and sociological impacts
    7. Economic: personal and business income impacts, tax revenue impacts, federal and state assistance
    8. Climate and Weather: meteorological monitoring and analysis (The Climate and Weather IT may, at the discretion of the department director, be named a standing committee)
    9. Post Drought Evaluation: review and analysis of impacts of drought on items 1 through 7, recommendations for mitigation, crisis intervention and planning, recommended changes and expansions to the Missouri Drought Plan.

Phase 3 - Conservation Phase

Phase 3 is activated:

- when the Palmer Drought Severity Index is between -2 to -4;
- when the DAC determines that activities designated to occur during Phase 3 are necessary, and in the appropriate areas;
- and when streamflows, reservoir levels and groundwater levels continue to decline, and forecasts indicate an extended period of below normal precipitation. Monitoring, oversight, and analysis activities are then increased. The Conservation Phase would return to a Drought Alert:
- when precipitation increases, streamflows, reservoir levels and groundwater levels stop their decline, and when the Palmer Drought Index rises to -2.0 or higher or the DAC determines Phase 3 activities are no longer required based on other drought determination methods listed in the section on Defining Drought.

The Drought Impact Team (see Appendix 2) and Local Teams (see Appendix 8) evaluate plan performance and report to the DAC. See Appendix A, for details of Water Conservation.

Phase 4 - Drought Emergency (Possible Local Rationing Phase)

Phase 4 is activated:

- when the Palmer Drought Severity Index exceeds -4.0; and/or
- when the DAC determines that Phase 4 activities are required by using drought determination methods listed above. The Governor may be requested to issue a Drought Emergency. An Executive Order for an agricultural disaster declaration shall be drafted by the Department of Agriculture, and a Health and Public Safety Declaration shall be drafted by SEMA.

The Governor's declaration empowers State agencies to review allocation of supplies in communities not adequately responding to their water shortage, and to implement emergency programs and actions. This may include provisions for limiting installation of service to new customers.

Drought Executive Committee (DEC): The Governor activates the DEC independently or after review of recommendation of the DAC. The DEC is composed of agency heads or their designee and other appropriate state representatives who have authority to commit agency staff and resources to respond to drought emergencies. The DEC membership may include members of the DAC who have authority to act on behalf of the agency head in this capacity. The DEC is chaired by the Director of the Department of Natural Resources or an appointee named by the Governor and meets on a regular basis for the purpose of administering and coordinating drought assistance in Missouri. The Committee is charged with developing short and long-term recommendations and options for the Governor as they relate to all aspects of drought response and management, including public health, safety and welfare, social, economic, and

environmental concerns. Recommendations and options will be based upon data and information provided by the DAC. The DEC membership will consist of the following representatives or their designee:

Governor's Delegate, designated by the Governor
President Pro Tem to make two appointments, one majority member and one minority member
Speaker of the House to make two appointments, one majority member and one minority member
Attorney General
Director, Department of Natural Resources
Director, Department of Health
Director, Department of Agriculture
Director, Department of Economic Development
Director, Department of Conservation
Administrator, Employment Services
Director, Department of Public Safety
Chairman, Public Service Commission
Director, State Emergency Management Agency

Activation of a State Emergency Operations Center (EOC): The EOC, as provided for in the SEMA's Emergency Operations Plan, should be operating at various levels of activation throughout a drought in accordance with four Crisis Action System (CAS) levels for assessment and response:

(a) CAS-1 Normal monitoring phase (Phase 1),
(b) CAS-2 DAC monitoring (Phase 2),
(c) CAS-3 Partial EOC activation recommended by DAC to the Governor (Phase 3), and
(d) CAS-4 Full EOC activation as recommended by the DEC to the Governor (Phase 4).

When the Missouri Emergency Operations Center is activated, procedural plans, pursuant to SEMA's Drought Annex to the Emergency Operations Plan, will need to be implemented as soon as possible. EOC staffing and operations at the four CAS levels are described in SEMA's Emergency Operations Plan.

ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

ORGANIZATIONAL OVERVIEW

FEDERAL

The following organizations of the federal government may be requested to assist Missouri during drought emergencies with data, information, loans, grants and programs for material and personnel support:

U.S. Department of Agriculture
U.S. Department of Commerce
U.S. Department of Labor
U.S. Army Corps of Engineers
U.S. Department of Interior
U.S. Environmental Protection Agency
Small Business Administration
Federal Emergency Management Agency
General Services Administration

During a Presidentially declared drought emergency, FEMA may provide Emergency Response Teams (ERTs) in the State EOC to assist in the coordination of federal assistance.

The DAC and/or DEC should seek the assistance and participation of the National Drought Policy Council and the National Drought Mitigation Center for drought response implementation activities and intergovernmental coordination.

STATE

The following state organizations may provide programs to local governments during drought emergencies:

Department of Natural Resources
Department of Health
Department of Agriculture
Department of Conservation
Department of Public Safety
Department of Economic Development
Department of Social Services
University of Missouri Extension Service
Crowder College

Monitoring by the DAC will be maintained throughout Phase 2 through Phase 4 with appropriate State assessment and response/recovery recommendations made to the Governor and the DEC.

Although some State assistance and resources are released for local use prior to formal declaration of a drought emergency by the Governor, most State assistance is available only after a State declaration or regional declaration by local authorities has been issued.

Attention should be given to overall water quality during all phases of any drought event, to ensure potable water for public use.

LOCAL

The following should also be considered as adjuncts to any plans, procedures, policies, and laws related to drought that local communities have developed:

- Enactment of ordinances to assure equitable water distribution. Provisions for limiting installation of service to new customers during Phase 4, provided that human health and safety shall be the determining factor.
- Establishment of a Water Management Team made up of major water users, government executives, health, fire, and police representatives, and utilities. This team will determine and implement community activities (See Appendix 8, for details of Water Management Team representation).
- Local drought plans prepared by local authorities (See Appendix 4 for a Local Response Plan) in coordination with the terms of the State Emergency Operations Plan (EOP) as well as local EOP's.
- Establish public information and education programs for local drought emergencies.
- Maintain communications/coordination with the state EOC throughout the drought emergency.
- Evaluate local vulnerability to water shortages (See Appendix 5).

ASSIGNMENT OF RESPONSIBILITIES

1. Department of Natural Resources

a. Provide chairperson(s) for CWC, DAC, and DEC,
b. Develop, as necessary, updates of Missouri Drought Plan for DAC review and approval.
c. Refer to sections A, B, C, and D in the Missouri EOP for state activation, alert, communications, public information and coordination functions applicable for all emergencies.
d. Monitor water resources (quality and quantity) and report to the director or chair of the DAC under Phase 1.
e. Provide information on available water resources within the state.
f. Contact city officials and other appropriate local officials to encourage adoption and enforcement of ordinances regarding conservation of water use.

g. Review and work with local communities to update regional water-supply plans for each community as requested by the DAC.
h. Assist water users to develop water conservation plans and programs.
i. Monitor hydrologic and water supply conditions, gather and interpret water data regarding supply, use and trends.
j. Continue to collect water use data, publish annual reports and analyze usage statewide and regionally.
k. Assist in education of the public concerning general water management needs and answer requests for water resource information.
l. Assist in mediating conflicts of source utilization.
m. Provide technical information regarding private water supplies.
n. Recommend voluntary cutbacks in water usage.
o. Initiate recommendations for water conservation based upon recognized priorities.
p. Coordinate with the Department of Health on release of drought-related health advisories.
q. Assist in encouraging all types of water conservation.
r. Chair the Climate and Weather Committee and Public Water Supply Impact Team.
s. Delegate staff for CWC, IT and DAC membership.
t. Develop reservoir firm yield studies.
u. Develop groundwater awareness areas in adverse drawdown situations.

2. Department of Agriculture

a. Chair the Agricultural Impact Team.
b. Coordinate with U.S. Department of Agriculture in collection of information regarding critical shortages of food products and livestock feed.
c. Develop state request for federal assistance and declaration of drought-related agricultural emergencies in coordination with the U.S. Department of Agriculture.
d. Plan for the emergency distribution of livestock feed.
e. Assist in encouraging cutbacks in agricultural use of water.
f. Delegate staff for IT and DAC membership.
g. Provide programs and assistance to local governments and individuals during drought emergencies.

3. Department of Public Safety

a. Coordinate the use of Missouri National Guard water trailers, pipe and pumps for use by local communities.
b. Refer to the State of Missouri Emergency Operations Plan for state activation, alert, communication, public information and coordination functions applicable for all emergencies.
c. Coordinate drought-related press releases.
d. SEMA will operate the EOC.
e. Coordination of state and federal resources as prescribed in the State Emergency Operations Plan and Drought Annex.

f. SEMA will develop a state request, if necessary, for federal disaster declaration and federal assistance in drought emergencies.
g. Delegate staff for IT and DAC membership.

4. Department of Health

a. Provide increased surveillance of private water supplies.
b. Provide public instructions on means of disinfecting drinking water.
c. Provide technical information regarding private water supplies.
d. Delegate staff for IT and DAC membership.

5. Department of Conservation

a. Implement drought assistance programs as requested and technical assistance pertaining to fish and wildlife.
b. Provide assessments of drought damage.
c. Delegate staff for IT and DAC membership.

6. Department of Economic Development

a. Provide direct technical assistance and technical assistance funding
b. Regulated investor owned utilities advise Public Service Commission (PSC) of their drought status, establish contact person for weekly status report, and recommend conservation education plans.
c. Advise PSC regulated investor-owned utilities to enforce their tariffs with regard to voluntary and mandatory conservation measures.
d. Provide weekly reports on current status of PSC regulated investor-owned utilities ability to provide service to their customers. The weekly reports will also contain any information the PSC drought coordinator would deem necessary to assist the Drought Assessment Committee.
e. Monitor all events that impact on this or other PSC regulated utilities during this emergency.
f. Delegate staff for IT and DAC membership.

7. Department of Social Services

a. Implement drought assistance programs as requested.
b. Provide assessments of drought damage.
c. Delegate staff for IT and DAC membership.

8. University of Missouri-Columbia: State Climatologist

a. Monitor weather and drought indices year round.
b. Provide information on available climate resources within the state.
c. Monitor and report any meteorological changes that may increase or decrease drought intensity by one phase.
d. Assist CWC, DAC and Impact Teams with access to real time weather data monitoring resources.
e. Coordinate efforts with the Chair of the Climate and Weather Committee to provide current weather and drought information to the public.

f. Create and update, on the University of Missouri internet web-site, public information on drought conditions, climate outlook and future projections.

9. University of Missouri Extension Service

a. Coordinate with Regional Extension Specialists for local drought preparedness/response/recovery activities.
b. Provide information and reports to the CWC and DAC on drought notifications and conditions in counties.
c. Assist Regional Extension Specialists in distribution of drought related Emergency Public Information.
d. Delegate staff for CWC, IT and DAC membership.

10. U.S. Department of Commerce - National Weather Service

a. Monitors weather forecasts year around and participates in the standing Climate and Weather Committee (CWC).
b. Provides numerous on-line information services.
c. Provides staff for the DAC and technical support to the CWC.

11. U.S. Department of Agriculture - Natural Resources Conservation Service, Farm Services Agency, Rural Development Administration, and Missouri Agricultural Statistics Service.

a. The Missouri Agricultural Statistics Service (MASS) develops and compiles county statistics useful in the monitoring of drought impacts. MASS compiles rainfall, soil moisture, pasture, and crop conditions statewide and makes these available via the internet. MASS provides staff to the CWC, DAC, and Agriculture Impact Team.
b. The Farm Service Agency (FSA) works in collaboration with the State Department of Agriculture and the Governor's Office to provide disaster financial assistance to farmers harmed by drought. Local county elected FSA representatives request assistance. If the last 3 months rainfall is less then 40 percent of normal, than the Missouri FSA in consultation with Missouri's Agriculture Department will inform the Governor. The Governor may then elect to request federal assistance for the impacted and adjoining counties. The FSA provides staff to the DAC and Agricultural Impact Team.
c. The National Resource Conservation Service (NRCS) provides technical expertise on surface water supplies to the DAC and information on PL 566 projects that are used or could be used for water supply. The NRCS has also supplied sediment surveys to the local water supply districts and Missouri Department of Natural Resources for remaining water supply estimates and reservoir firm yield projections. The NRCS provide staff representation to the DAC.

d. The Rural Development Administration (RDA) provides staff to assist the DAC and the Drinking Water Impact Team. Rural Development Administration is the major federal player in assisting rural districts drought proof their systems in advance of a drought. The RDA can also provide funds for pipeline construction to move water to where it is needed the most. A strong RDA water supply program is crucial to the long-term water supply delivery in many rural areas of Missouri.

12. U.S. Army - Corps of Engineers

a. The Corps of Engineers may supply emergency water pumps and pipelines and water hauling upon request of the DAC or the Governor. The Corps will not supply water for industrial, commercial, or agricultural purposes. Emergency water supplied is for domestic emergency water supplies only.
b. The Corps provides staff to support the activities of the DAC and the Communications Impact Team.

13. U.S. Department of the Interior - U.S. Geological Survey, Water Resources Division

a. The United States Geological Survey (USGS) provides online capability for internet monitoring through satellite links. The USGS compiles Missouri Department of Natural Resources statewide water well level monitoring. Well monitoring data is useful in determining the impacts of drought upon groundwater supplies.
b. The USGS along with several cooperators, including the Department of Natural Resources operates and maintains a statewide stream-gaging network. The stream-gaging network is crucial in determining drought impacts upon surface waters and springs.
c. The USGS provides expert staff to support the DAC.

14. U.S. Environmental Protection Agency

a. EPA assists by providing staff to the DAC and the Environmental impact Team.
b. The U.S. EPA is a major player in providing federal funds to Missouri Public Drinking Water Program through matching state resources to improve public drinking water systems safety and drought vulnerability.

15. Federal Emergency Management Agency

a. Provides staff to support the DAC.
b. The Federal Emergency Management Agency (FEMA) and the State Emergency Management Agency will become very active in a Phase 4 drought emergency condition. The FEMA may provide emergency relief to impacted families.

16. Small Business Administration

a. Implement drought assistance programs as requested.
b. Provide assessments of drought damage.
c. Delegate staff for IT and DAC membership.

17. U.S. Department of Energy

a. Implement drought assistance programs as requested.
b. Provide assessments of drought damage.
c. Delegate staff for IT and DAC membership.

CONCLUSIONS

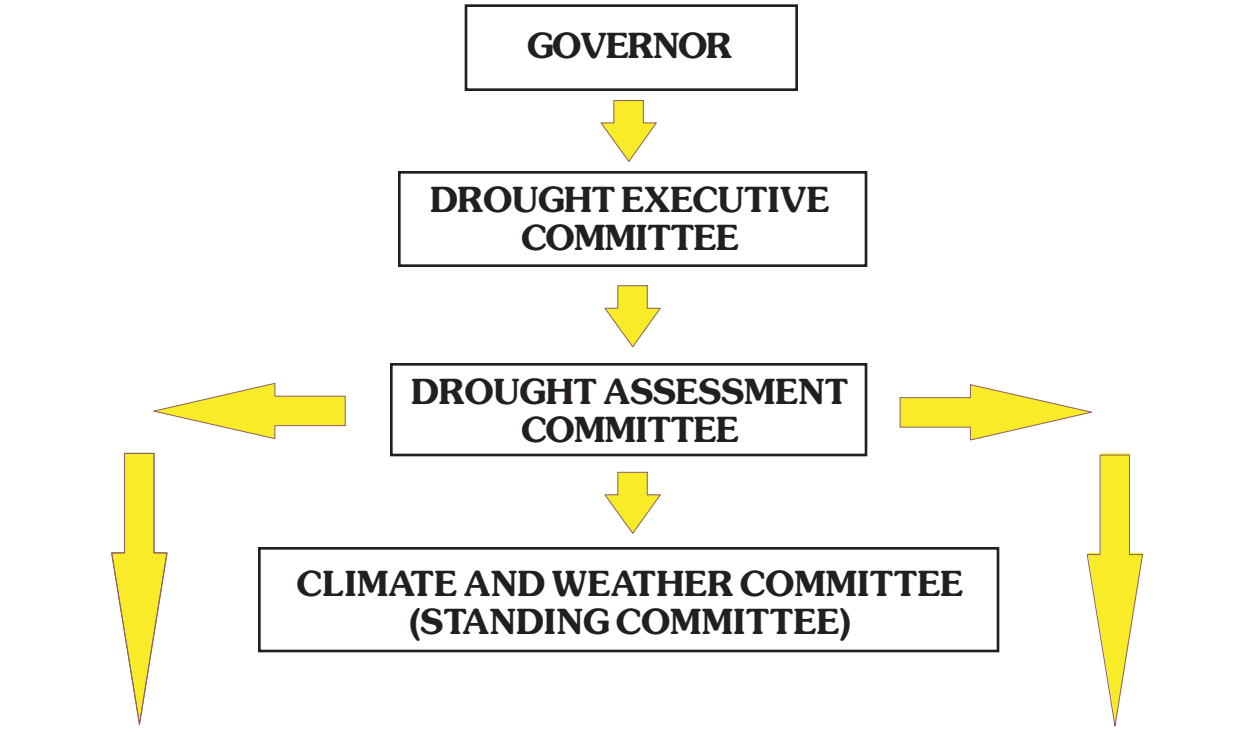
The objectives of this drought plan are specific and action-oriented. The plan incorporates activities related to drought mitigation planning and drought response. The breadth of drought impacts requires coordinated, yet timely actions. To be successful, this plan and the actions of the Drought Assessment Committee/Drought Executive Committee (DAC/DEC) must have the support and close participation of the Executive and Legislative branches of Missouri state government. Agreement within state agencies and with special and public interest groups is also an important part of implementation.

Since no plan can anticipate all issues under all conditions, the active participation by the DAC and the DEC is critical for successful drought response. This plan provides a framework of general guidance. Creative and far-ranging response activities, specific to meet the situation at hand are anticipated and expected. Deviation from specific terms of this plan is expected and proper, dependent on the circumstances.

Planning, if undertaken properly and implemented during non-drought periods, can improve governmental ability to respond in a timely and effective manner during periods of emergencies. The costs of preparedness are reduced considerably through the use of existing institutional structures and by incorporating the process into a comprehensive state water planning effort. Examples would include: the development of regional water supplies and transmission systems, firm yield evaluation for all water supply reservoirs, and drought flow sustainability studies for all vulnerable river drinking water supply intakes. Utilities should also be encouraged to use available funds to upgrade metering. If leaks are detected, they should be repaired or distribution piping replaced where necessary.

APPENDIX 1

Missouri Drought Plan Organizational Chart



APPENDIX 2

STATE DROUGHT IMPACT TEAMS

Each state agency named to an Impact Team (IT) will name an agency drought coordinator and, by their own initiative, take appropriate measures in response to drought related problems. Not all drought impacts will be represented by the available data, therefore, the IT must look for adverse drought effects not reflected in the data. Coordination with other agencies and timely implementation of effective measures by individual agencies should not be hindered by a strict review and approval process. The Impact Teams will coordinate and facilitate individual agency actions and oversee cooperative efforts. The representatives must be able to speak for their agency and have authority to make reasonable commitments toward effective cooperation and coordination.

The ITs will function as technical work groups to specifically assess the impact and needs of the areas they are established to monitor. Each Impact Team activated by the DAC will, at time of activation, be charged with specific tasks and duties.

The duties and activities of the Impact Teams are to include, but are not limited to the following:

- Establish procedures for coordination with other Impact Teams, state and federal agencies, local government, and public/or private groups.
- Identify key contacts in state, federal, and private support groups.
- Review existing reporting, analyze capabilities, and identify information gaps. Recommend response levels and activities and analyze barriers to response or special needs.
- Report to the Drought Assessment Committee (DAC) on a regular basis as determined by the DAC.
- Maintain supporting data and records of activities.
- When deactivated, prepare a final summary report on activities and submit it to the Director or Chair of the Drought Assessment Committee.
- The final summary report should include proactive recommendations that will help to mitigate and prevent future drought related problems, specific to the charge of the Impact Team.

APPENDIX 3

SUGGESTED RESPONSE PRIORITY WATER-USE CLASS

Class 1: Essential Water Uses

Domestic Use: Water in amounts reasonably needed to sustain human life, and to maintain reasonable standards of hygiene, cleanliness, and sanitation.

Health Care Facilities: Patient care and rehabilitation

Public Use: Firefighting - local authorities should institute a "burn ban" at this time, allowing no outside burning.

Water that is necessary for health and public protection purposes, as specifically approved by the health official and the municipal governing body, should include public water supply and wastewater treatment.

Water is necessary for the operation of electric power generation, essential for the operation of key military facilities, the operation of telephone communications, water and wastewater systems and other health-related needs.

Class 2: Socially or Economically Important Uses of Water

To the extent that sources of water other than fresh water are not available or feasible to use, socially or economically important uses of water include:

(a) agricultural irrigation for the production of food and fiber and the maintenance of livestock;
(b) watering by commercial nurseries at a minimum level to maintain stock;
(c) water uses by arboretums and public gardens of national, state, or regional significance where necessary to preserve specimens;
(d) water use by sod producers and the turf industry to a minimum level to maintain stock;
(e) use of fresh water at a minimum rate necessary to implement revegetation following earth moving, where such revegetation is required pursuant to an erosion and sedimentation control plan adopted pursuant to law or regulation;
(f) commercial laundromats;
(g) restaurants, clubs and eating establishments;

(h) commercial air conditioning, including refilling for start-up at the beginning of the cooling season, make up water during the cooling season, refilling specifically approved by health officials and the municipal governing body where the system has been drained for health, protection or repair purposes; and
(i) schools, churches, motels/hotels, similar commercial establishments.

Class 3: Non-Essential Uses of Water

Non-essential uses of water include:
(a) outdoor commercial and non-commercial watering (public or private);
(b) fountains, reflecting pools and artificial waterfalls used for ornamental purposes;
(c) gardens, lawns, parks, playing fields and other recreational areas that do not have access to grey water supplies;
(d) filling and operation of swimming pools (public or private);
(e) watering of golf course greens to the extent that sources of water other than fresh water (e.g. such as grey water) are not available or feasible to use;
(f) washing of all motor vehicles including commercial car and truck washes and private vehicles by owner except in cases involving recognized human health and safety concerns (e.g. ambulances, commercial vehicles that haul fresh produce, etc.);
(g) use of fire hydrants and sprinkler caps for testing any fire apparatus and for fire department drills (unless specifically approved by the health officials of the municipality). In general, the use of fire hydrants for all purposes except for fire fighting, health protection or certain testing and drills by the fire department if it is in the interest of public safety and is approved by the governing body.
(h) any flushing of sewers and hydrants except as needed to ensure public health and safety, and approved by health officials and the governing body;
(i) air conditioning and refilling cooling towers after draining except for refilling for start-up at the beginning of the cooling season, makeup of water during the cooling season, refilling specifically approved by health officials and the governing body where the system has been drained for health protection or repair purposes.

APPENDIX 4

A LOCAL WATER SHORTAGE RESPONSE PLAN
(under local ordinances)

This plan is the responsibility of the local water shortage management team. This group provides essential support to officials making difficult decisions during water shortage times. It is also responsible for determining how much water is available, and how much will be needed. If the assessment shows no potential for shortage, then officials should continue to monitor the supply and be prepared to act if the situation changes. If the assessment of supply and demand shows the potential for a water shortage, the Team should begin planning to take the following actions, as needed:

1. Advise local water utilities to locate and correct leaks,
2. Explore possibilities for supplementing the water supply such as regional water supply and interconnection with other water utilities,
3. Consider changing pricing to discourage water use (should the drought last for an extended period of time or be severe),
4. Advise the community to take conservation measures according to the severity of the shortage.
5. Aspects of the Missouri Drought Plan may be tested and exercised on a regular basis under the State Emergency Operations Plan administered by the State Emergency Management Agency.

There are four phases of severity:

Phase 1 - Advisory Phase

During the Advisory Phase do the following:

(a) issue a water shortage advisory as indicated by the DAC or as local conditions dictate,
(b) set conservation goals,
(c) inform the public of the potential problem, and
(d) request voluntary conservation.

When to declare an advisory:

(a) an advisory should be declared when conditions indicate the potential for serious water-supply shortages,
(b) when static water levels drop in wells, or when pumping rates decline, or when drawdowns increase while pumping (measurements should be made weekly),
(c) when streamflow is abnormally low, or when demand is 20 to 40 percent of flow,
(d) when there are less than 240 but more than 180 supply days left in reservoirs and impoundments (supply should be reassessed weekly).

What to do in an advisory:

(a) notify the affected public and request voluntary conservation expressed as a percentage of normal use or a specific gallon amount,
(b) conduct an intensive public information campaign,
(c) enlist support from the local Water Shortage Management Team because they are important to success,
(d) allow for the fact that in most circumstances, voluntary measures only reduce water use by 5 to 15 percent,
(e) develop action plans for alternate supply sources. The action plans would be constructed from plans developed as drought contingencies as approved by the local Water Shortage Management Teams.
(f) establish water conservation ordinances that have enforceable measures for non-compliance. Recommended water conservation for specific uses should be activated at this point.

Phase 2 - Drought Alert

During the Drought Alert do the following:

(a) issue a water shortage alert as indicated by the DAC or as local conditions dictate,
(b) set more stringent conservation goals, which can include activities to educate utility owners and operators that unaccounted water (water lost in transmission) must be measured and reduced to a reasonable limit such as 10 to 15 percent,
(c) restrict Class 3 non-essential uses,
(d) inform the public of the problem,
(e) request voluntary conservation of all water use, and
(f) monitor and enforce compliance.

When to declare an alert:

(a) when there are visible or measurable signs that supplies are significantly lower than the seasonal norm and are diminishing,
(b) when there are signs of shortage in a well that are abnormally large or there is a rapid increase in drawdown or a large decrease in the static water level,
(c) when the demand is 40 to 65 percent of flow of springs or streams, as determined from comparisons with historical records (the flow should

be measured twice weekly. The alert can be removed when demand is less than 40 percent for a 4-week period.),

(d) when there are less than 180 but more than 120 days supply remaining in a reservoir impoundment (for reservoirs in small watersheds, more conservative figures are appropriate).

What to do in an alert:

(a) choose and implement voluntary measures (restrict specific Class 3 uses) and incorporate enforceable water use restrictions into a water conservation ordinance (if not previously done).

(b) implement an education effort to encourage water conservation intensified to exceed 50 percent water conservation,

(c) develop a firm commitment to alternate supply processes such as pipelines, hauling, and agreements with nearby water supplier.

Phase 3 - Conservation Phase

During the Conservation Phase:

(a) issue a water shortage statement, with coordination from the DAC

(b) set more stringent conservation goals,

(c) ration Class 3 use, restrict Class 2 use,

(d) inform the public,

(e) enact conservation pricing, and

(f) monitor/enforce compliance/restrictions.

When to declare Phase 3:

(a) if the drawdown and static water level of a well continues to go down, a point should be chosen to declare an emergency situation based on prior knowledge of the well,

(b) if the demand on springs and streams is 65 to 75 percent of flow (measure the flow daily),

(c) when there are less than 120 but more than 60 days available supply in reservoirs and impoundments (The time frame is especially critical for supplies in small drainage basins so the supply should be reassessed daily).

What to do in Phase 3:

(a) implement stringent conservation measures,

(b) enact pricing measures and additional mandatory restrictions (economic rationing), indicate Class 2 and Class 3 use restrictions.

(c) expanded educational efforts and explain pricing measures and restrictions,

(d) put water conservation ordinance in place

(e) put alternate supply sources into service, and

(f) assess penalties for non-compliance with the water conservation ordinance (penalties should be graduated for repeat violations).

Phase 4 - Drought Emergency (water rationing)

During the Water Rationing Emergency Phase:

(a) begin mandatory allocation of water and advise the DAC of local emergency,
(b) immediately reduce usage by 25 to 50 percent (local option),
(c) inform the public,
(d) practice stricter conservation pricing,
(e) set new conservation goals,
(f) monitor all shortages and compliance,
(g) enforce allocations as necessary, and
(h) Ban Class 2 and 3 uses.

When to declare water rationing:

(a) when the water supply is clearly inadequate to meet predicted demands, declare water shortage rationing on metered systems. Unmetered users must somehow be monitored. Efforts should be implemented to finance meters prior to drought.
(b) when the supply appears to be running out in water wells;
(c) when demand on springs and streams is 75 percent or more of their daily measured flow;
(d) when less than 60 day supply is available in reservoirs and impoundments.

What to do in rationing:

(a) be fair and equitable,
(b) use the method most appropriate for your community (if you use flat percentages it penalizes conservation but if you use variable percentages it is better for small users),
(c) penalty assessments established earlier are to be enforced,
(d) set a maximum allowable usage,
(e) allow maximum per capita use (rationing and pricing can reduce use of water by 30 to 70 percent).

Secured Water Allocation to individual users: This would only occur at times when the supply was almost totally depleted, and would only be for life-threatening cases.

In many shortage situations, finding additional supplies is impractical. Planning (RESOP and Firm Yield studies) and conservation measures designed to maintain supplies are frequently more effective than last minute attempts to supplement supplies.

Provisions for limiting installation of service to new customers may need to be considered, where the addition of new customers would cause impairment of existing service to tenured customers in the form of low water pressure, bacterial contamination and increased costs to original customers. Limitation of service to new customers should be reviewed on a case-by-case basis with human health and safety being the primary factor.

The review should include the following secondary considerations:

(a) individuals who previously refused service during normal, non-drought conditions,
(b) normal construction of new residential dwellings and refurbishment of existing dwellings that would typically require public water service hook-up under normal conditions,
(c) normal business or industrial construction or development where public water service would be required,
(d) pre-planned and previously approved water service expansion, long term implications for an area's economic, social and environmental stability and growth.

During extremely severe drought, the Governor should, at the recommendation of the DEC, declare mandatory allocation of water in communities not adequately responding to water shortages.

When the situation has returned to normal, the Advisory, Alert, Conservation, and Emergency phases should be decreased in reverse order of implementation. It would be wise to have a buffer period prior to starting a return to normal conditions. Too rapid a return could be disastrous if drought conditions persisted. Water shortage response efforts and results should be recorded and evaluated for use during future problems.

The Department of Natural Resources' Public Drinking Water Program has good examples of local drought plans. It would be advisable for local communities to see these plans and create a plan which best fits their conditions. The most important thing is to have a plan that can be implemented.

APPENDIX 5

EVALUATING VULNERABILITY AND DEMAND

Missouri could avoid or postpone many impacts of drought if citizens and communities were already conserving and using their water resources more efficiently. To encourage wise use, state and federal agencies should consider offering Water Consumption Audits for all categories of water usage.

Evaluating Vulnerability to Water Supplies

Several factors influence the determination of whether raw water supply and storage are adequate:

1. Reliability - How often has the volume of source approached the current level of demand, and under what conditions?
2. Resilience - How quickly would the source recover from a shortage?
3. Flexibility - How accessible are alternate sources?
4. Expansion of Service Area - What impacts would accompany installation of service to new customers on tenured customers and conversely the impacts of denial of service to new customers?
5. Transmission Losses - How much raw and treated water is lost by leaking transmission lines?
6. Public Safety - What are the requirements to maintain adequate levels of human health, safety and welfare as it pertains to drinking water, fire protection, adequate water pressure, and prevention of water system contamination?

Determination of Ability to Meet Demand

If demand is normally 80 percent of system capacity, it is likely to reach 100 percent or more if there is a drought. Conservation is the only method of coping with demand that surpasses treatment and distribution capacity.

Each situation must be analyzed separately by local governments and water utility managers to determine how to respond to a watch or warning.

1. Estimating demand: a well-operated water utility may have as much as 15 percent loss, and many systems have 30 percent or more. In estimating demand you should include:
   (a) true losses related to leakage, metering and billing systems
   (b) the percent of total water pumped that is accounted for at service meters
   (c) the estimated amount of water that is unmetered

Future demands and water use projections should be performed by a qualified economist. Contact the Department of Natural Resources, U.S.D.A. Natural Resource Conservation Service (NRCS) or a consultant for advice.

2. Estimating supply:
   (a) Use specific capacity to determine the "wellness" of your wells. There is cause for concern when the capacity decreases to 80 percent. Static water levels and drawdowns should be measured on a regular basis.
   (b) Without historical records for the wells, a supply/demand figure cannot be determined. Current drawdown and specific capacity figures must be used. Monitoring for a few weeks can tell if the well is significantly decreasing in supply capability due to low water or overdrawn conditions. Groundwater consultants, the USGS and the departments' Geological Survey and Resource Assessment Division, Water Resources Program can assist in determining well capability and spacing needs.
   (c) Monitor the elevation or stage of water in the impoundments through use of a staff gage.
   (d) Contact the NRCS and the department to determine if reservoir sediment surveys have been made on the impoundment. If surveys have been made so that volumetric estimates can be made for the reservoir bottom contours, then estimate the volume of storage remaining. The elevation of the top of the surface water intake structure should be used as the bottom of the reservoir for calculating the remaining storage available. Due to summer stratification and chemical processes associated with the hypolimnion of stratified reservoirs, the bottom one-third of many Missouri reservoirs is very difficult to process for water supply. The bottom one-third often contains excessive levels of iron, manganese, organics and turbidity. Accumulated sediments may also deplete storage so sediment survey information is critical during times of low reservoir capacity and must be known to calculate the firm yield of a reservoir.
   (e) If available, daily flows into and out of the reservoir are useful in determining reservoir yield. To be reliable, evaporation and reservoir seepage also must be taken into account. The department recommends using the Drought of Record (1953-1957) to determine the critical period, and calculations of inflow and evaporation to determine future inflows during a drought cycle and for all new water supply reservoirs. Engineering consultants are available to assist with these calculations. Advice can be obtained from the NRCS, the department, and USGS.
   (f) Many small water supply impoundments were originally designed with very little carryover storage. A safe and reliable groundwater supply system should be designed to operate under extreme drought conditions and be able to withstand the 5-year drought of the 1950s. Interconnections and agreements between suppliers are very productive in time of water supply or distribution outages.

APPENDIX 6

POST-DROUGHT EVALUATION PROCEDURES

The Drought Assessment Committee may address Post-Drought Evaluation by addressing the following questions as a part of the evaluation process:

(1) Was the drought plan followed? If not, why?
(2) Were the actions taken and measures implemented effective in mitigating the impact of the drought? Which actions and relief measures were effective and which were not?
(3) Should the plan have included other actions or assistance measures?
(4) Did aid reach all affected groups in the stricken area? If not, why not? How were the target groups for aid identified?
(5) Were the measures timely in relation to the events of the drought period?
(6) Was it possible to correct errors during the emergency?
(7) What financial and human resources were allocated to the relief effort? Where did the resources come from and how were they controlled?
(8) How efficient was the logistical support and the available infrastructure? What obstacles were encountered that reduced the efficiency of the response?
(9) How effective was the coordination of state and federal response efforts? How did this cooperation affect the flow of information or assistance?
(10) Was media coverage accurate and realistic in providing details of the event? What kinds of media were involved? What role did they play in the emergency?

The following questions are an example of a post-drought evaluation review designed by the Kentucky EPA to assist in evaluating drought response. Many of them are modeled after questions developed by the International Drought Information Center.

(1) What unit of your agency was active in the water shortage response? How was this decided?
(2) What are the normal responsibilities of this section? Has drought response been incorporated in the operations of this unit?
(3) How were upper level managers kept informed of activities? With what frequency?

(4) What are the responsibilities of your agency in case of drought-related water shortages? What information or cooperation do you need from other agencies to carry them out? Was this communication and activity adequate? How could it be improved?

(5) What other agencies did you report to during the drought? What media were used and with what frequency? Name of person responsible. Was the result satisfactory?

(6) What other agencies reported to yours? What media were used and with what frequency? Who was responsible? Was the result satisfactory?

(7) Were the actions taken by your agency effective in mitigating the impacts of drought? Which measures were effective and which were not? What activities should be added?

(8) What financial and human resources were allocated to the relief effort? Where did the resources come from and how were they controlled? How much time and money were involved?

(9) Please provide any impact estimates prepared by your agency. Include costs, losses, and gains from the drought, in terms of dollars and/or the impact on the environment and resource base.

(10) Any other recommendations or comments?

APPENDIX 7

WATER CONSERVATION

The measures listed below are suggestions for wise water use. They are listed by use and condition. Naturally, all such measures are even more appropriate during worsening drought conditions.

INDOOR RESIDENTIAL USE

CONSERVATION FOR NORMAL CONDITIONS AND ADVISORY PHASE

- Use dishwashers only when they are full. Washing dishes by hand (don't let the tap run!) saves about 25 gallons.
- Adjust water level on clothes washing machines, if possible. Use full loads only if not adjustable.
- Turn off faucets while brushing teeth, etc. This saves about 5 gallons per day.
- Reduce water used per flush by installing toilet tank displacement inserts. A plastic jug can be used as an alternative. Do not use bricks as they can disintegrate when soaked and the resulting grit hinders closing of the flap valve.
- Do not use the toilet as a trash can.
- Use sink and tub stoppers to avoid wasting water.
- Keep a bottle of chilled water in the refrigerator for drinking.
- Find and fix leaks in toilets, which can leak silently. The following method can be used to see if this is occurring: place a drop of food coloring in the upper tank and do not flush for 30 minutes. If color appears in the bowl, there is leakage.
- Find and fix leaks in faucets and water-using appliances. Faucets can usually be fixed cheaply and quickly by replacing washers.
- Adapt plumbing with flow-restricting or other water-saving devices. These are usually inexpensive and easy to install. See list of devices in Appendix C.
- Learn to read your water meter so you can judge how much water you use and what difference conservation makes.

CONSERVATION FOR ALERT AND ADVISORY PHASE (in addition to measures listed above)

- Take shorter showers and shallower baths. Saves about 25 gallons.
- Reduce the number of toilet flushes per day. Each flush uses about 5 gallons (2-3 gallons if you have water-saving toilets).
- Dont use a garbage disposal.
- Use non-phosphate detergent and save laundry water for lawns and plants.

CONSERVATION MEASURES FOR EMERGENCY WATER CONSERVATION AND RATIONING PHASES (in addition to measures listed above)

- Turn off shower while soaping up.
- Use disposable eating utensils.

OUTDOOR RESIDENTIAL USE

CONSERVATION FOR NORMAL CONDITIONS AND ADVISORY PHASE

Lawns

- Water before 10:00 A.M. to prevent evaporation, which occurs during the hottest part of the day. Morning is better than evening, when the dampness encourages growth of fungus.
- Water only when lawn shows signs of wilt. Grass that springs back when stepped on does not need water.
- Water thoroughly, not frequently; long enough to soak roots. A light sprinkling evaporates quickly and encourages shallow root systems. Water slowly to avoid runoff.
- Do not let the sprinkler run any longer than necessary. In an hour, 600 gallons can be wasted.
- Allow maximum of one inch of water per week on your lawn. To measure, place cake tins outside to collect rain and water from sprinklers.
- Use pistol-grip nozzles on hoses to avoid waste when watering flowers and shrubs.
- Aerate lawns by punching holes 6 inches apart. This allows water to reach roots rather than run off surfaces.
- Mow Kentucky bluegrass no shorter than 2 to 3 inches high, to hold moisture.
- Position sprinklers to water the lawn, not the pavement.
- Avoid watering on windy days when the wind not only blows water off target, but also causes excess evaporation.
- Keep sprinkler heads clean to prevent uneven watering.
- Adjust hose to simulate a gentle rain. Sprinklers that produce a fine mist waste water through evaporation.
- Know how to turn off an automatic sprinkler system in case of rain.
- Use an alarm clock or stove timer to remind you to shut off sprinklers that dont have timers.

Vegetable and Flower Gardens

- Water deeply, slowly and weekly. Most vegetables require moisture to a depth of six to eight inches.
- Keep soil loose so water can penetrate easily.
- Use mulch around plants and between rows to hold in moisture.
- Keep weeds out to reduce competition for water.
- Put the water where you want it and avoid evaporation by using soil-soakers or slow-running hoses, not sprinklers.

Trees and Shrubs

- Water deeply using a soil-soaker.
- Water only when needed. Check the depth of soil dryness by digging with a trowel. While the surface may be dry, adequate moisture may be retained beneath the surface.
- Mulch to reduce evaporation. A 2 to 3 inch layer of wood chips, pine needles, grass clippings, or straw keeps the soil cool in summer. Mulch adds landscape interest and reduces weeds, and the few weeds that do grow are easy to uproot.
- Dig troughs around plants to catch and retain water.
- Water plants growing in full sun more often than those in shade.
- Do not use sprinklers. Apply water directly at base of plant.
- Do not fertilize during the summer. Fertilizing increases a plants need for water.
- Postpone planting until fall or spring when there is generally less need for water.
- Install trickle-drip irrigation systems close to the roots of your plants. By dripping water slowly, the system doesn't spray water into the air where it can be lost through evaporation. Use soil probes for large trees.
- Water when it is cloudy, at night, or even when a light rain is falling.

CONSERVATION MEASURES FOR ALERT AND EMERGENCY CONSERVATION PHASES (in addition to measures listed above)

- Do not allow children to play with hose or sprinklers.
- Limit washing driveways, vehicles, machinery, etc.
- Be ready to catch rainfall that occurs. Place containers under downspouts.
- Use leftover household water, if available.
- Consider delaying the seeding or sodding of new lawns.
- Determine the amount of water being used outdoors by comparing water bills for the summer and winter.

CONSERVATION MEASURES FOR ALERT CONDITIONS (if outdoor watering is allowed in addition to measures listed above)

- Vegetable gardens and food trees should be given minimal amounts of water on an individual basis only.
- Do not water lawns and inedible plants.
- Do not use sprinklers.

Most outdoor watering is prohibited under emergency conditions.

HOSPITAL AND HEALTH CARE FACILITY USE

- Reduce laundry usage or services by changing bed linen, etc., only when necessary to preserve the health of patients or residents.
- Use disposable food service items.
- Eliminate, postpone, or reduce, as may be appropriate, elective surgical procedures during the period of emergency.

INDUSTRIAL USE

- Identify and repair all leaky fixtures and water-using equipment. Give special attention to equipment connected directly to waterlines, such as processing machines, steam-using machines, washing machines, water-cooled air conditioners, and furnaces.
- Assure that valves and solenoids that control water flows are shut off completely when the water-using cycle is not engaged.
- Adjust water-using equipment to use the minimum amount of water required to achieve its stated purpose.
- Shorten rinse cycles for laundry machines as much as possible; implement lower water levels wherever possible.
- For processing, cooling and other uses, either reuse water or use water from sources that would not adversely affect public water supplies.
- Advise employees, students, patients, customers, and other users not to flush toilets after every use. Install toilet tank displacement inserts; place flow restructure in shower heads and faucets; close down automatic flushes overnight.
- Install or adjust automatic flushing valves to use as little water as possible or to cycle at longer intervals.
- Place water-saving posters and literature where employees, students, patients, customers, etc. will have access to them.
- Check meters on a frequent basis to determine consumption patterns.
- Review usage patterns to see where other savings can be made.

APPENDIX 8

THE LOCAL WATER SHORTAGE MANAGEMENT TEAM

During years of drought, and in communities that regularly experience water shortages, a local water shortage management team is important to successful response. If water runs short in your community there will be difficult decisions to make. A water shortage management team can provide support for making and implementing those decisions, ensuring an appropriate and effective community response.

REPRESENTATION

A local team should be locally lead and include representatives of major water users, officials responsible for county health and safety, and persons who can help design and implement an effective information/education program. A reasonable size is 7 to 15 members. These could be chosen from the following sources. Those marked with an asterisk (*) are necessary participants.

Board of Health
Businesses (especially large water users)
Chamber of Commerce
Churches
* City Administration
Conservation District
Conservation Groups
* County Coordinator, Disaster and Emergency Services
County Health Department Officials
Regional Office Representatives (e.g. Missouri Department of Health, Missouri Department of Natural Resources, etc.)
Fire Chief
Industries (both self-supplied and publicly supplied water users)
* Legal representative
Media representatives (TV, radio and newspapers)
Police Chief
Professional Groups
Parent Teacher Associations
Superintendent of Schools
* Water District or Utility Personnel
Water Superintendent

APPENDIX 9

PRICING

The costs of running a utility during a drought (emergency hook-ups, publicity, etc.) will increase, while revenues from water sales will decrease (as consumers use less). Officials should consider a rate schedule to generate revenues during the drought, when users are likely to be more receptive to such measures. Systems governed by the Public Service Commission (PSC) must have its approval to change rates or rate schedules.

Although conservation pricing is important, it will not effectively reduce water use unless used in conjunction with an educational effort.

Measures that can be used on any system:

Seasonal rate - Higher rate during peak months. Effective when shortages and peak months coincide. Easy to administer and easy for users to understand. Must be adjusted so that rates are equitable per user.

Drought surcharge - Flat surcharge, regardless of use

Increasing block (progressive rate scale) - Higher rate charged per unit as total use increases. Rate rises in steps per block of volume

Measures that can be used on metered systems:

Conservation discount - Discount for reducing use below required conservation level

Excess use charge - Higher rate for use above a fixed amount per billing period

Penalty charge (in conjunction with rationing)

Flat charge - for use above a certain amount (baseline), with an increase for subsequent offenses. Penalty charge should be high. The baseline maximum use figure can be one per capita (if population records are up to date); or two per household. Large volume users consider the latter to be equitable. Administering baseline maximum programs that vary per household is difficult.

Disconnect/reconnect charge - Charge for ceasing and/or re-instituting service after rationing provisions have been violated.

APPENDIX 10

ASSESSMENT AND RECOMMENDATIONS FOR DROUGHT PLANS

State and local drought contingency groups should be formed at the earliest possible time and should have statewide, regional, and local plans in place before the next drought occurs. However, before any type of definite plan is formulated, a concerted effort for public input is mandatory.

Public hearings to elicit input into the content of state and local drought plans are necessary, particularly in the drought-prone regions. These efforts should be coordinated by the State Drought Assessment Committee. Although it is difficult to convince people, even those at the highest level of state government or in the General Assembly that drought planning is necessary when there is no drought, it must still be done. The objectives of drought policy can be achieved only if they are formulated by all parties involved in the process, and by those affected. If done properly, the resulting plan will be successful. Questions that must be addressed include:

(1) What is the role of state government in drought preparedness, response, mitigation and recovery?
(2) What is the scope of the plan (i.e. agricultural, cultural, or multi-impact)?
(3) What are the most drought-prone areas of the state in relation to the areas of greatest need?
(4) What are the most vulnerable sectors of the state's economy and the most necessary?
(5) Will a plan provide assistance to resolve conflict between users during periods of shortage? How?
(6) What resources is the state willing to commit to the planning and mitigation? This includes natural resources, human expertise, infrastructure, and capital.
(7) What legal, economic, political or social conditions affect water usage rates?
(8) What principal environmental concerns are associated with drought and how will the plan avoid or resolve conflicts between the environmental and economic sectors?
(9) Will short-term emergency responses conflict with the ability to achieve long-term goals? Other states have detailed drought plans in effect, and some states have hydrologic conditions that parallel Missouri's.

(10) What are the water use priorities? How will the water use priorities, as established in the Missouri Water Resources Law, be enforced? Who will carry out the necessary enforcement?

It is particularly important that drought emergency funding be sought at an early date to assure that monies are available when the need arises. It should be recognized that the financial resources available to government change annually and from one administration to the next. This may provide an additional incentive for the state to formalize its drought plan through state statute, thus assuring that funds are available to carry out the program. It may be possible to set up a drought/flood emergency relief fund.

Care must be taken to ensure that at least a minimum amount of pre-drought planning takes place at the local level. At present there is very little incentive to commit limited financial resources toward drought mitigation planning.

There are, almost certainly, legal constraints that will affect the drought plan as it is formulated. These include:

(a) methods available to control water use,
(b) the kinds of public trust laws in existence,
(c) requirements for contingency plans for water suppliers,
(d) emergency and other powers of the governor or state agencies during water shortages,
(e) interstate compacts, and
(f) water-quality standards.

It is imperative that any drought plan have some sort of evaluation process so that the plan can be updated or modified as needed. This evaluation should be an on-going process during droughts, and changes should be made as quickly as possible. However, prior to the advent of drought conditions and as a final step in the establishment of the plan, a detailed set of procedures needs to be adopted to ensure adequate evaluation of the plan. Two modes of evaluation must be in place:

(1) An ongoing or operational evaluation program that considers how changes such as new technology, legislative action, and changes in political leadership, may affect the operation of the plan;
(2) A post-drought assessment program that documents and critically analyzes the response actions of government and others as appropriate, and that implements recommendations for improving the system.

To ensure an unbiased appraisal, non-governmental organizations should be given responsibility for evaluating drought response efforts. The review team would address a prescribed set of questions regarding the response efforts. (See Appendix 6 for a sample set of evaluation questions.)

Missouri should encourage water conservation at all times, particularly in those areas that are more sensitive to drought conditions, when they occur. A drought in an area where the public is already used to conserving as a daily habit, will have less devastating effects. Tax incentives for water-conserving devices or appliances should be considered prior to the advent of drought conditions. These incentives or tax "breaks" for water conservation devices would be handled much the same as the energy conservation tax incentives are handled, except that the same "trigger mecha-

nisms" used to require drought conservation would be used to start the tax incentives. The incentives would be prorated for the duration of the drought. Tax incentives should be considered in the "water-poor" areas of the state as an on-going program, even in non-drought times. The incentives may be increased during drought conditions to offer further encouragement. Extending the tax incentives to include the installation of native drought-resistant plant species in new landscapes should also be considered.

Public education is very important and would be considerably easier during a drought, but this type of education needs to start prior to any drought. It needs to be emphasized in the schools and in the media over an extended period of time to instill the idea of water conservation in the public's mind. Throughout any drought alert or emergency the DAC report and internet updates are an important part of the communication process. The DAC report was very helpful to communities, planners, and state officials during the drought of 2000.

It may be possible to develop water-supply consortia along the lines of solid waste management districts. Members of the consortium would agree to share water with other members or sell water at a reasonable, prearranged cost during emergencies.

Another option would be for governmental agencies, such as the Department of Natural Resources, the Department of Conservation (MDC) or the Natural Resource Conservation Service (NRCS) to construct moderate-sized reservoirs that could be used most of the time for recreation, but would be available for water supply during droughts. Alternatively, the agencies could share the cost of the reservoir with area towns that would be able to use the supply at a prearranged rate during drought. It may be necessary to amend existing legislation that addresses water resources and water supplies to enable these activities to take place during drought emergencies. Again, care would need to be taken to place recreation at a lower priority during drought conditions so that the water supplies in the reservoirs could be used.

APPENDIX 11

ALTERNATIVES

The following list of alternatives is aimed primarily at those areas that are most vulnerable to problems of prolonged drought. Priority ranking of the alternatives listed is difficult. They are a mix of institutional, scientific, technical, social, political, local, state and federal options. The listing is probably not complete. However, all of the alternatives are important and should be implemented prior to the advent of drought conditions.

(1) Plan and build new reservoirs in those areas remote from water sources or where groundwater supplies are deficient. Assess the potential for connecting to, or jointly building with, another water system.

(2) Assess available water volumes (RESOP modeling and lake bathymetric studies) and enlarge existing reservoirs and clean mud and silt out of existing reservoirs to increase storage capacity.

(3) Gage streams and reservoir stages to determine storage figures and find a "trigger point" to require conservation and rationing during a drought.

(4) Supplement reservoir storage with pumping capacity from nearby flowing watercourse.

Instream diversions may require aquatic life support flows. Aquatic life support flows will be determined by the Department of Natural Resources upon consultation with Missouri Department of Conservation. These minimum in-stream flows will be determined by a qualified hydrologist and reflect water diversion requirements, aquatic life needs and all other down stream uses.

(5) If the supplemental water supply is a surface water stream intake, that is difficult to obtain due to limited flow conditions, build a low-head dam to increase water storage at the intake and/or build off-channel storage.

Instream diversions may require aquatic life support flows. Aquatic life support flows will be determined by the Department of Natural Resources upon consultation with Missouri Department of Conservation. These minimum in-stream flows will be determined by a qualified hydrologist and reflect water diversion requirements, aquatic life needs and all other down stream uses.

(6) Conduct drilling programs to determine the groundwater storage capabilities of nearby stream alluvium.

(7) Construct "gallery wells" or horizontal, screened interceptors in the thin alluvium and conventional wells in the thicker alluvium.

(8) Determine "trigger points" using long-range weather predictions to start mandatory conservation measures.

(9) Plan now for the interconnection of public water districts that have supplies that are adequate for drought conditions. This alternative is not without inherent problems. The potential impact of additional water demand on a supply also under drought conditions must be carefully considered. Reliance upon one major source in a crisis could result in having multiple supplies on the verge of total outage.

(10) Immediately make detailed plans and set up the mechanisms for temporary (or permanent) pipelines to furnish water to water-short communities for both short-term and long-term shortages. In all cases, the water supply source should be identified well in advance of drought.

(11) Set up mechanisms for hauling water by truck and railroad to supply communities in desperate water-shortage conditions. Priority should be given to developing compacts with the states of Kansas and Iowa in this matter.

(12) Where conditions indicate that it is geologically appropriate, deepen existing wells and/or lower pumps if water levels decline. If conditions permit, drill new wells to alleviate shortages. Deepening existing wells as a contingency for drought is hard to convince well owners to do.

(13) Form a permanent drought committee as part of a detailed drought plan at the executive branch of state government. The committee should include agency directors to make and implement drought contingencies. The committee would be activated by the Governor and would be called the Drought Assessment Committee (DAC) (see Concept of Plan Operations for DAC duties).

(14) Make needed interstate water quality and quantity compacts with neighboring states, to establish definite interstate flows during drought periods.

(15) Establish "conservation rate structures" which are triggered at a pre-determined Palmer Index (or some other method determined by the state) to be applicable to the affected area. These rate structures would charge a user more if he used over a certain minimum rather than the cost being lower as more water is used (See Appendix 9, for details of pricing during drought events). This type of conservation would be locally mandated, but could be tied to the future availability of state grant monies. It has been suggested that it might be wise for some communities to have these rates in effect at all times to encourage conservation. The City of Wichita, Kansas, has had success with this strategy.

(16) Establish agreements such as Memorandums of Understanding (MOU) with commercial, private lake owners or government agencies having operational control of lakes that could serve as water-supply sources to furnish an agreed upon amount of water to nearby water supplies during drought

emergencies. The means of transmitting set amounts of water would have to be determined at the time of agreement. Water quality would be one of the prime requirements for an agreement. Any such agreement should be underwritten with the conservation measures mentioned in alternative 14.

(17) Identify sites or locations for water loading stations for rural area water haulers.

(18) And perhaps the most important alternative is to have a detailed drought plan to handle all phases of the drought as it occurs. Drought planning is too often done after a drought has begun, making it reactionary rather than preventive. In most instances, there are very few options for mitigating drought damages once a drought is in progress.

(19) The long-term alternative of water system regionalization either compliments or incorporates the previously listed alternatives 8, 9, and 16. Water system regionalization would serve to mitigate the impacts of drought through construction of regional supplies, distribution and storage facilities, management consolidation, water system consolidation, and water and wastewater district formation, along with water system regionalization is applicable for raw, treated freshwater systems and wastewater systems.

(20) Determine sustainable drought yields on flow studies for all year round streams.

(21) Evaluate all year round streams for aquatic resource needs (in-stream flow) for fish and macroinvertebrate health during drought and low flow periods.

In October 1994, water system regionalization was identified as a priority that needs implementation in governmental units.

The Public Drinking Water Program, Department of Economic Development and Public Service Commission are promoting interconnection and regionalized systems.

November 1994 - REGIONALIZATION SUPPORT STATEMENT

State and federal agencies should cooperatively encourage and place a high priority on funding projects directed at regionalization, and consider it a plus in the criteria for allocating grants and loans. Agencies should also support other entities actively developing regional systems. This should not preclude the eligibility of a system that requires an exemption or variance of the regionalization concept if a feasibility study certified by the agency indicates a regional system is not feasible.

Source: Regionalization Work Group, tasked by the Agriculture and Natural Resources Committee of Missouri Rural Opportunities Council. S.A. McIntosh, Chairman

APPENDIX 12

MAPS

This appendix contains a series of maps that the reader may use to determine, in a general way, a variety of water use parameters across Missouri. The data used in these maps were gleaned from the 2000 U.S. Census and the United States Geological Survey (USGS) Water-Use website (http://www.usgs.gov/ Every five years the USGS compiles national water-use estimates and publishes a report. The information used in many of the following maps comes from this report (Circular 1200, "Estimated Use of Water in the United States in 1995"). For clarity purposes, it is important to list some selected definitions used by the USGS.

Estimated Use of Water in the United States in 1990 Glossary of water-use terminology

Water-use terminology is continuing to expand in this series of water-use circulars prepared at 5-year intervals. The term "water use," as initially used in 1950 in the U.S. Geological Survey's water-use circulars, meant withdrawals of water; in the report for 1960, the term was redefined to include consumptive use of water as well as withdrawals. With the beginning of the Survey's National Water-Use Information Program in 1978, the term was again redefined to include return flow and offstream and instream uses. In the report for 1985, the term was redefined to include withdrawals plus deliveries.

STANDARD WATER-USE TERMS

commercial water use—water for motels, hotels, restaurants, office buildings, other commercial facilities, and institutions. The water may be obtained from a public supply or may be self supplied. See also public supply and self- supplied water.

domestic water use—water for household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens. Also called residential water use. The water may be obtained from a

public supply or may be self supplied. See also public supply and self-supplied water.

groundwater—generally all subsurface water as distinct from surface water; specifically, that part of the subsurface water in the saturated zone (a zone in which all voids are filled with water) where the water is under pressure greater than atmospheric.

hydroelectric power water use—the use of water in the generation of electricity at plants where the turbine generators are driven by falling water. Hydroelectric water use is classified as an instream use in this report.

industrial water use—water used for industrial purposes such as fabrication, processing, washing, and cooling, and includes such industries as steel, chemical and allied products, paper and allied products, mining, and petroleum refining. The water may be obtained from a public supply or may be self supplied. See also public supply and self- supplied water.

irrigation water use—artificial application of water on lands to assist in the growing of crops and pastures or to maintain vegetative growth in recreational lands such as parks and golf courses.

livestock water use—water for livestock watering, feed lots, dairy operations, fish farming, and other on-farm needs. Livestock as used here includes cattle, sheep, goats, hogs, and poultry. Also included are animal specialties. See also rural water use and animal specialties water use.

million gallons per day (Mgal/d)—a rate of flow of water.

per capita use—the average amount of water used per person during a standard time period, generally per day.

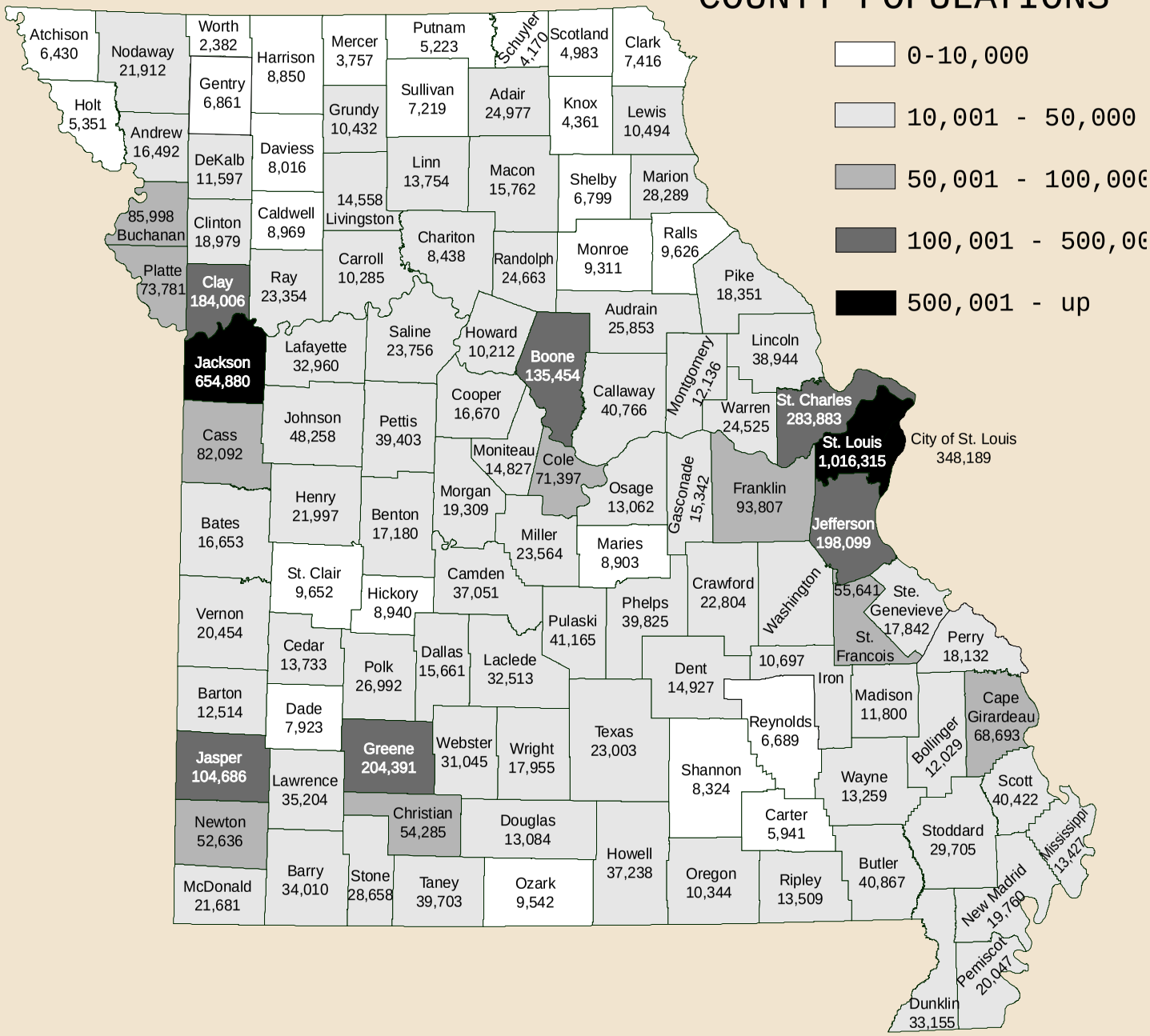
public supply—water withdrawn by public and private water suppliers and delivered to users. Public suppliers provide water for a variety of uses, such as domestic, commercial, thermoelectric power, industrial, and public water use. See also commercial water use, domestic water use, thermoelectric power water use, industrial water use, and public water use.

self-supplied water—water withdrawn from a surface- or ground-water source by a user rather than being obtained from a public supply.

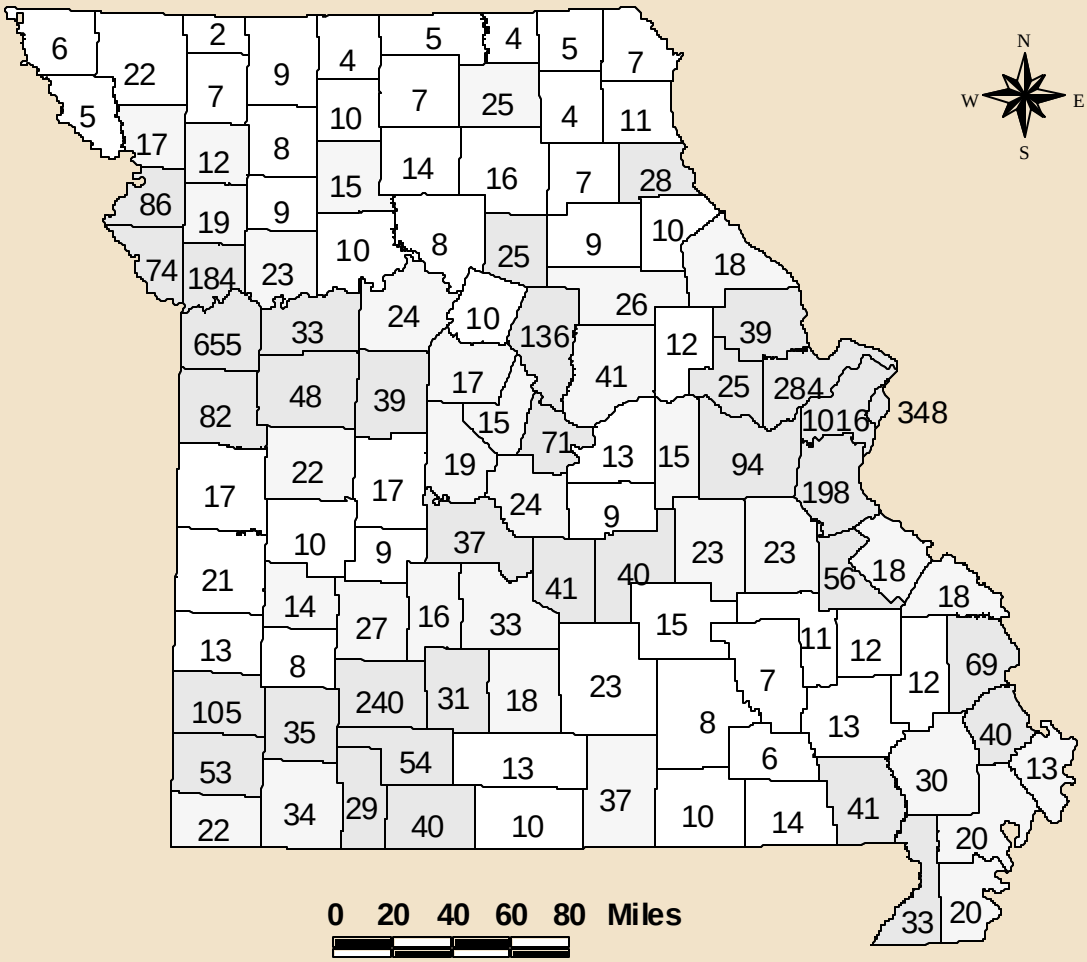
surface water—an open body of water, such as a stream or a lake.

thermoelectric power water use—water used in the process of the generation of thermoelectric power. The water may be obtained from a public supply or may be self supplied. See also public supply and self-supplied water.

water use—1) in a restrictive sense, the term refers to water that is actually used for a specific purpose, such as for domestic use, irrigation, or industrial processing. In this report, the quantity of water use for a specific category is the combination of self-supplied withdrawals and public-supply deliveries. 2) More broadly, water use pertains to human's interaction with and influence on the hydrologic cycle, and includes elements such as water withdrawal, delivery, consumptive use, wastewater release, reclaimed wastewater, return flow, and instream use. See also offstream use and instream use.


COUNTY POPULATIONS
0-10,000
10,001 - 50,000
50,001 - 100,000
100,001 - 500,00
500,001 - up
Atchison 6,430
Nodaway 21,912
Worth 2,382
Harrison 8,850
Mercer 3,757
Putnam 5,223
Schuyler 4,170
Scotland 4,983
Clark 7,416
Holt 5,351
Andrew 16,492
Gentry 6,861
Daviess 8,016
Grundy 10,432
Sullivan 7,219
Adair 24,977
Knox 4,361
Lewis 10,494
DeKalb 11,597
Caldwell 8,969
14,558 Livingston
Linn 13,754
Macon 15,762
Shelby 6,799
Marion 28,289
85,998 Buchanan
Clinton 18,979
Platte 73,781
Clay 184,006
Ray 23,354
Carroll 10,285
Chariton 8,438
Randolph 24,663
Monroe 9,311
Ralls 9,626
Pike 18,351
Audrain 25,853
Jackson 654,880
Lafayette 32,960
Saline 23,756
Howard 10,212
Boone 135,454
Callaway 40,766
Montgomery 12,136
Warren 24,525
Lincoln 38,944
St. Charles 283,883
St. Louis 1,016,315
City of St. Louis 348,189
Cass 82,092
Johnson 48,258
Pettis 39,403
Cooper 16,670
Moniteau 14,827
Cole 71,397
Osage 13,062
Gasconade 15,342
Franklin 93,807
Jefferson 198,099
Bates 16,653
Henry 21,997
Benton 17,180
Morgan 19,309
Miller 23,564
Maries 8,903
St. Clair 9,652
Hickory 8,940
Camden 37,051
Crawford 22,804
Washington 55,641
Ste. Genevieve 17,842
St. Francois
Perry 18,132
Vernon 20,454
Cedar 13,733
Polk 26,992
Dallas 15,661
Laclede 32,513
Pulaski 41,165
Phelps 39,825
Dent 14,927
10,697 Iron
Madison 11,800
Barton 12,514
Dade 7,923
Greene 204,391
Webster 31,045
Wright 17,955
Texas 23,003
Reynolds 6,689
Bollinger 12,029
Cape Girardeau 68,693
Jasper 104,686
Lawrence 35,204
Shannon 8,324
Wayne 13,259
Scott 40,422
Newton 52,636
Christian 54,285
Douglas 13,084
Carter 5,941
Stoddard 29,705
Mississippi 13,427
McDonald 21,681
Barry 34,010
Stone 28,658
Taney 39,703
Ozark 9,542
Howell 37,238
Oregon 10,344
Ripley 13,509
Butler 40,867
New Madrid 19,760
Pemiscot 20,047
Dunklin 33,155

POPULATION AND POPULATION DENSITY

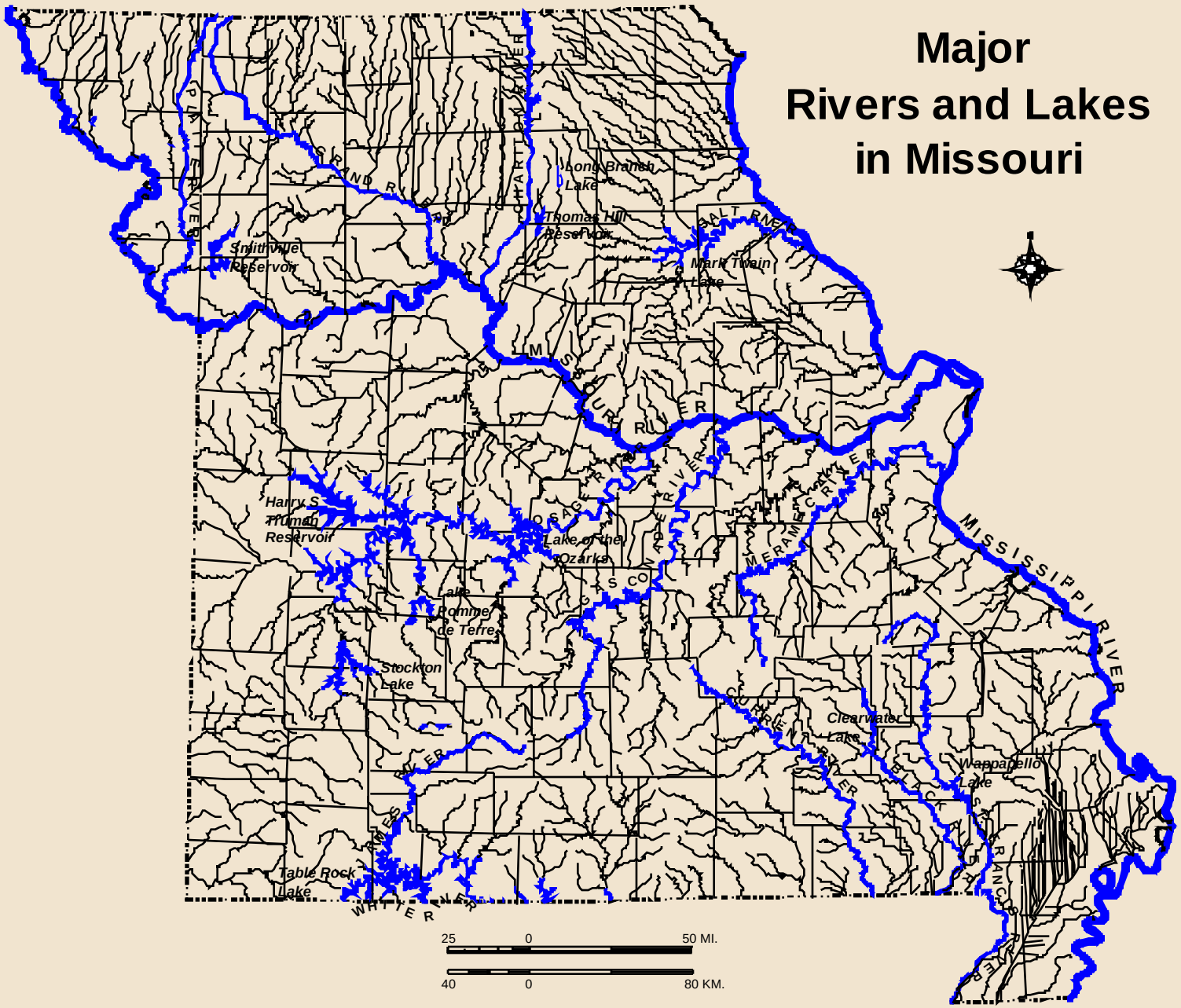


People per square mile

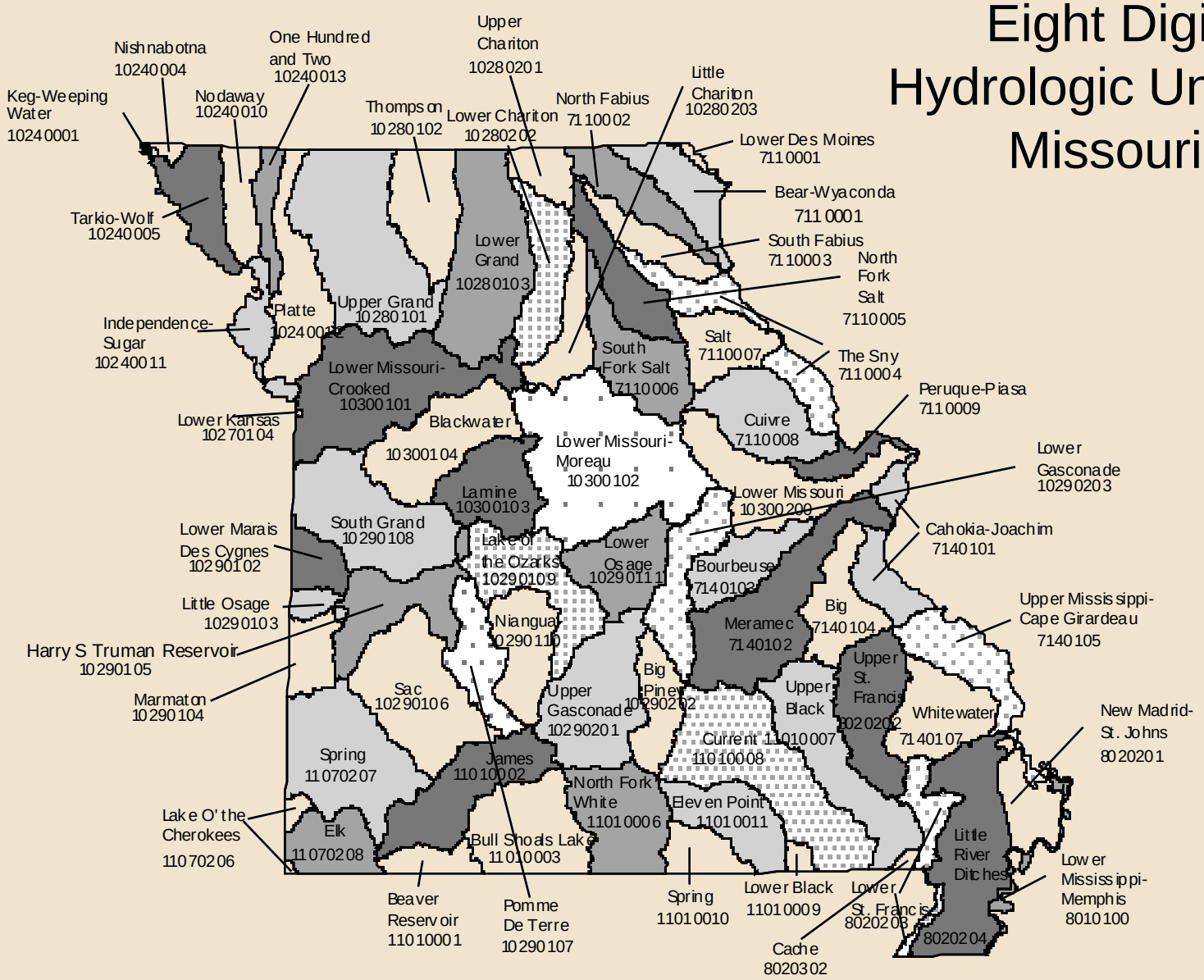
- **8-25**
- **26-50**
- **51-100**
- **101-200**
- **200+**

Number = 2000 US Census population for that county (in thousands)

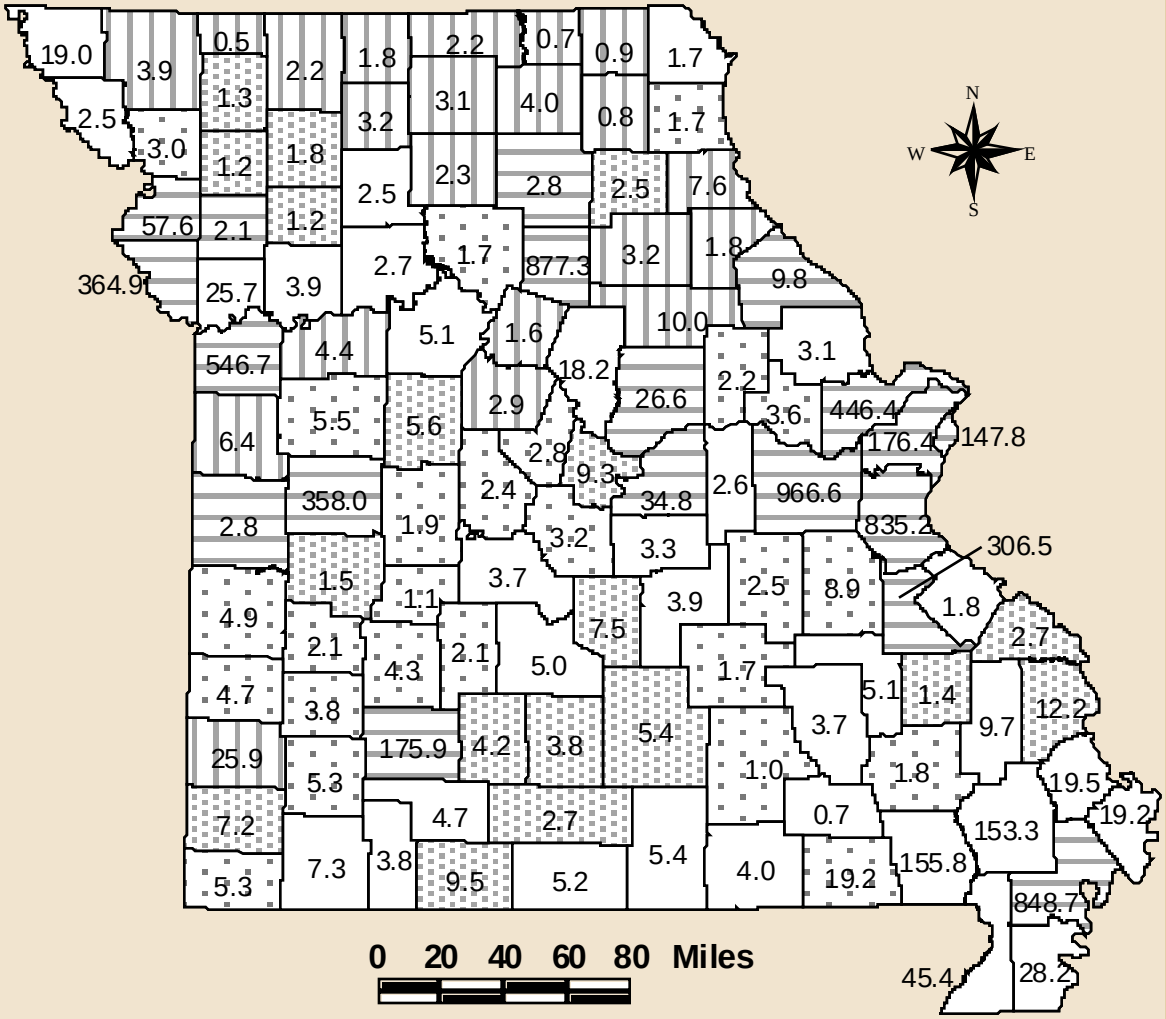
Source: US Census Bureau, 2000 census data


Major
Rivers and Lakes
in Missouri
PLATTE RIVER
GRAND RIVER
CHARITON RIVER
LOCUST CREEK
LITTLE
Long Branch
Lake
Thomas Hill
Reservoir
SALT RIVER
Smithville
Reservoir
Mark Twain
Lake
MISSOURI RIVER
OSAGE RIVER
GASCONADE RIVER
MERAMEC RIVER
Harry S
Truman
Reservoir
Lake of the
Ozarks
Lake
Pomme
de Terre
Stockton
Lake
MISSISSIPPI RIVER
CURRENT RIVER
Clearwater
Lake
Wappapello
Lake
BLACK RIVER
WHITE RIVER
Table Rock
Lake
25 0 50 MI.
40 0 80 KM.

Eight Digit Hydrologic Units of Missouri



TOTAL WATER USE



% of Supply from Surface Water (remainder from groundwater)

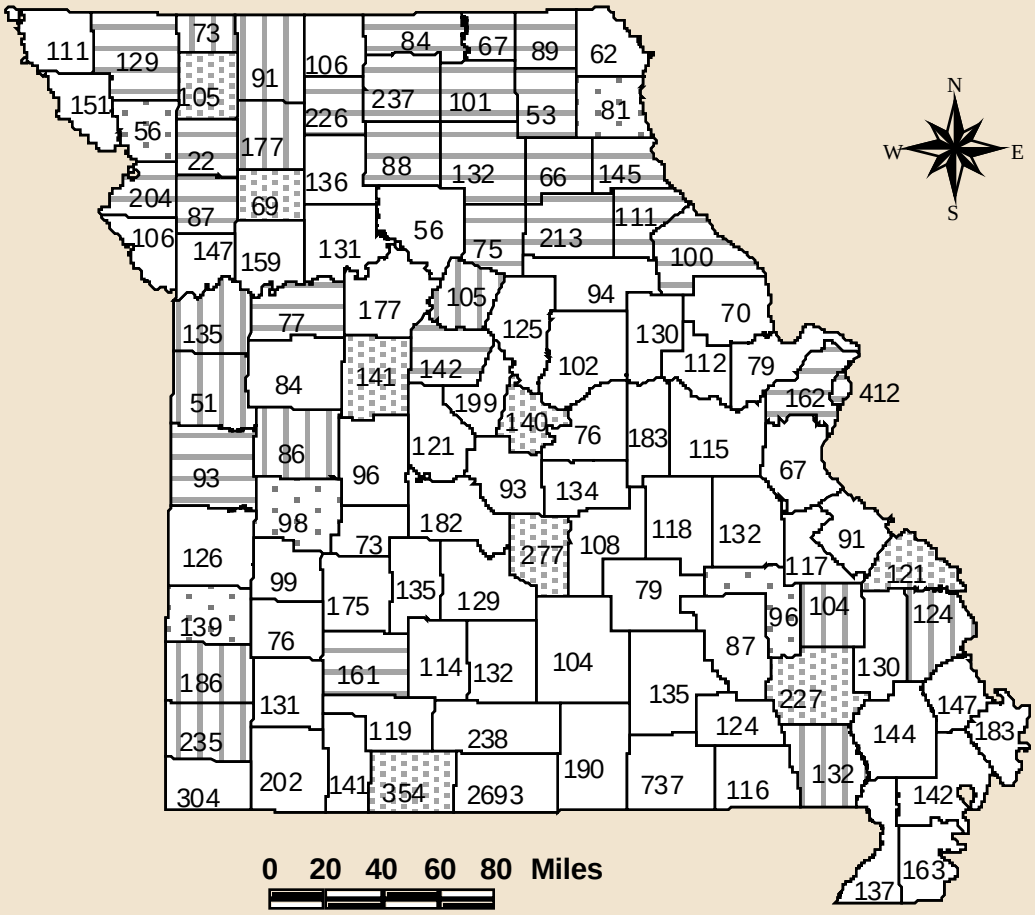
- **0-20**
- **21-40**
- **41-60**
- **61-80**
- **81-100**

Number = Total water use for that county (Mgal/day)

Source: USGS 1995 Water Use Data for Missouri
http://water.usgs.gov/watuse/spread95.html

WATER USE FROM PUBLIC SUPPLIES

See definition - page 53



% of Supply from Surface Water (remainder from groundwater)

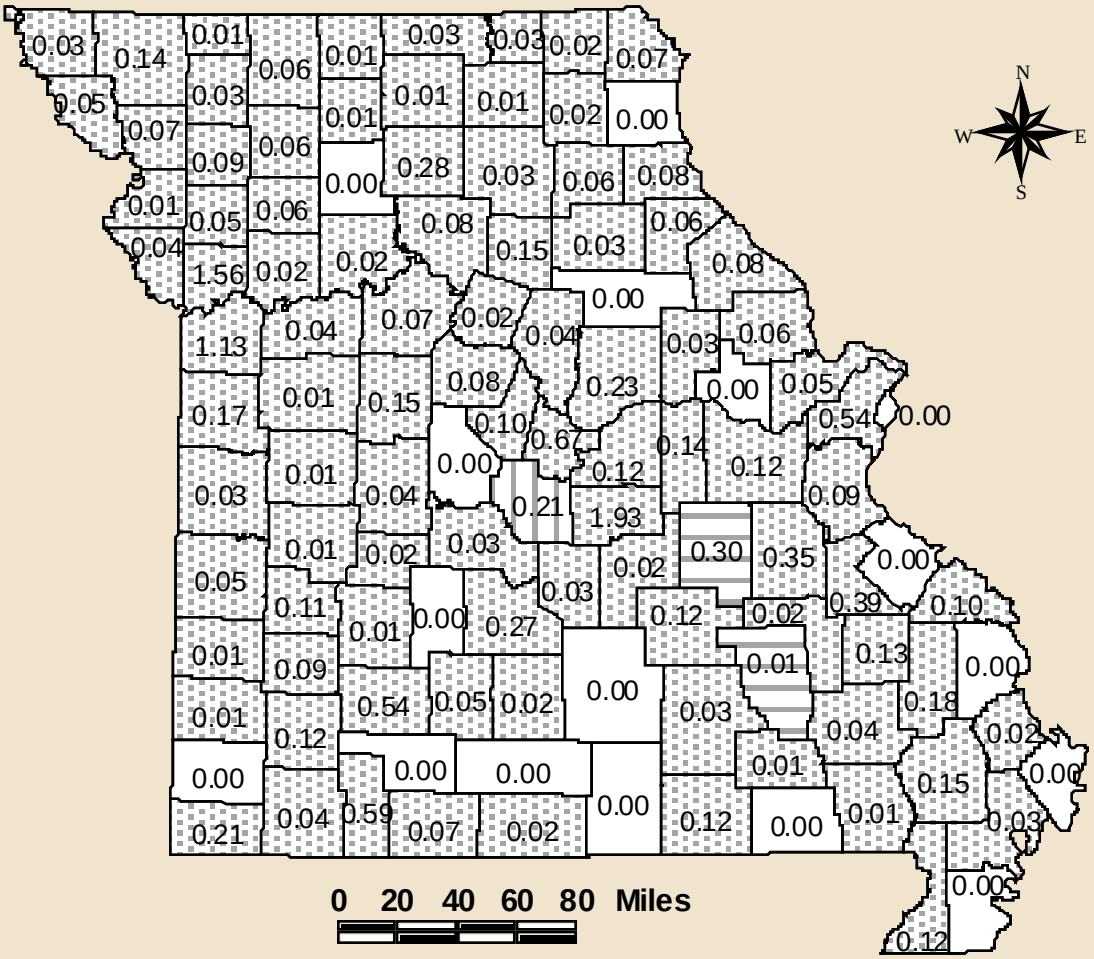
- **0-20**
- **21-40**
- **41-60**
- **61-80**
- **81-100**

Number = Public Supply per capita water use for that county (gal/day)

Source: USGS 1995 Water Use Data for Missouri
http://water.usgs.gov/watuse/spread95.html

SELF-SUPPLIED COMMERCIAL WATER USE

See definition - page 52



% of Supply from Surface Water (remainder from groundwater)

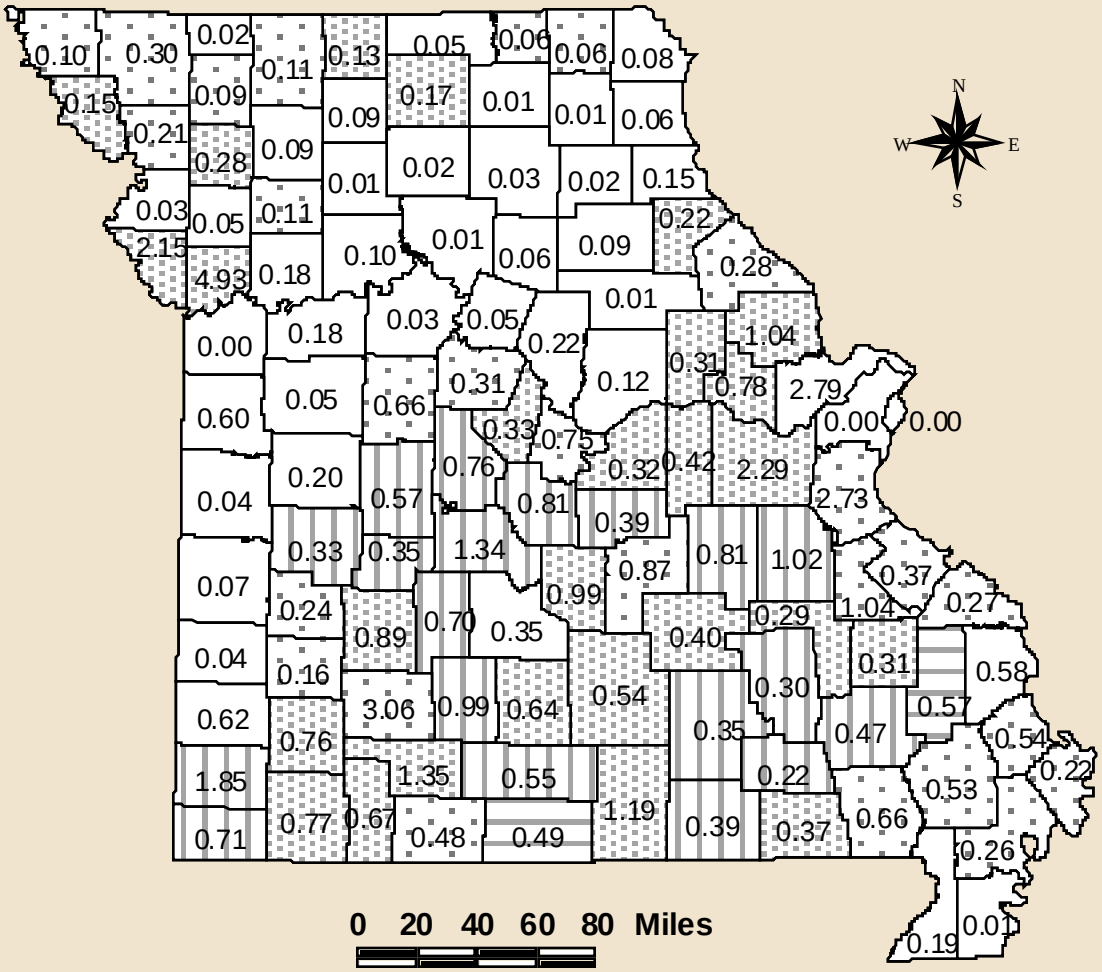
- **no commercial water use**
- **0-20**
- **61-80**
- **81-100**

Number = Commercial water use for that county (Mgal/day)

Source: USGS 1995 Water Use Data for Missouri
http://water.usgs.gov/watuse/spread95.html

SELF-SUPPLIED DOMESTIC WATER USE

See definition - page 53



of supply from surface water (remainder from groundwater)

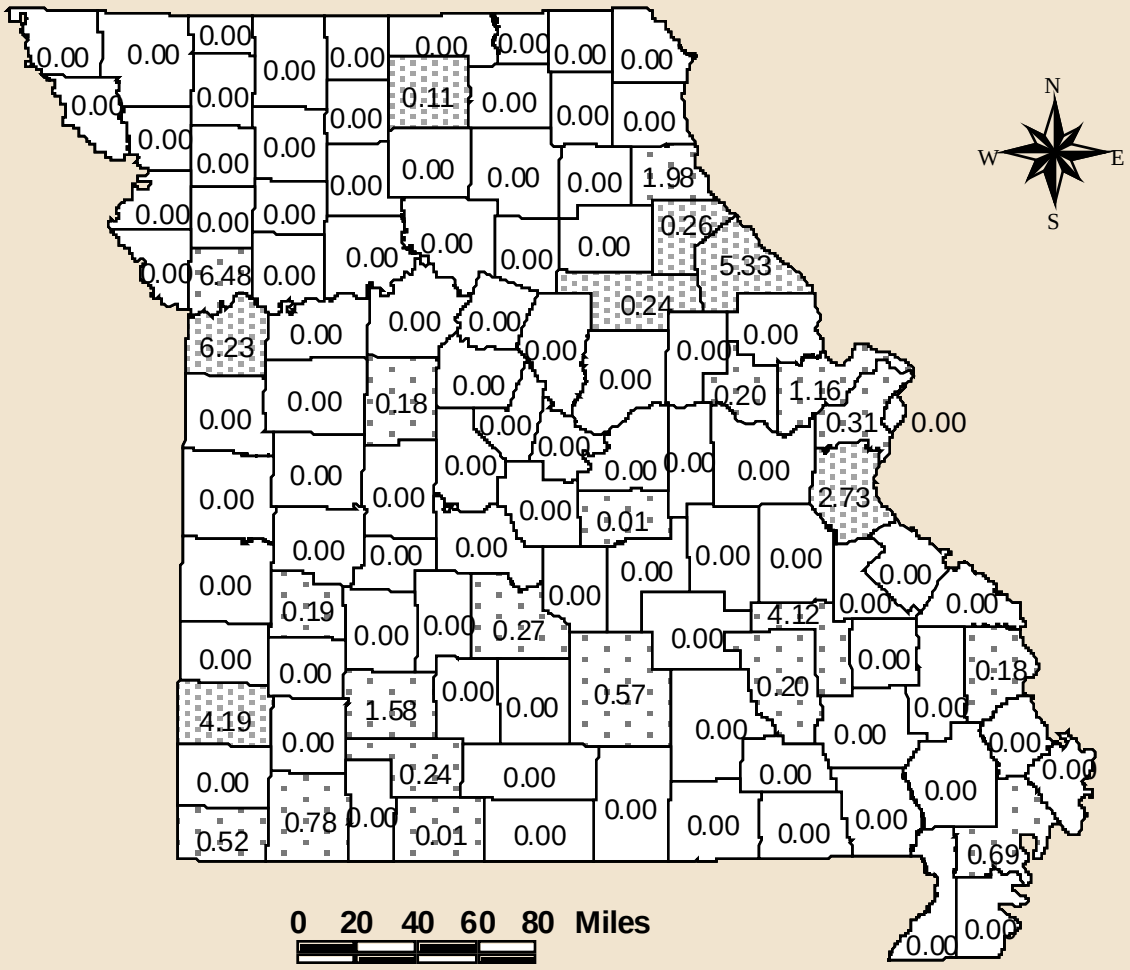
- **0-20**
- **21-40**
- **41-60**
- **61-80**
- **81-100**

Number= Domestic water use for that county (Mgal/day)

Source: USGS 1995 water use data for Missouri
http://water.usgs.gov/watuse/spread95.html

SELF-SUPPLIED INDUSTRIAL WATER USE

See definition - page 53



% of Supply from Surface Water (remainder from groundwat

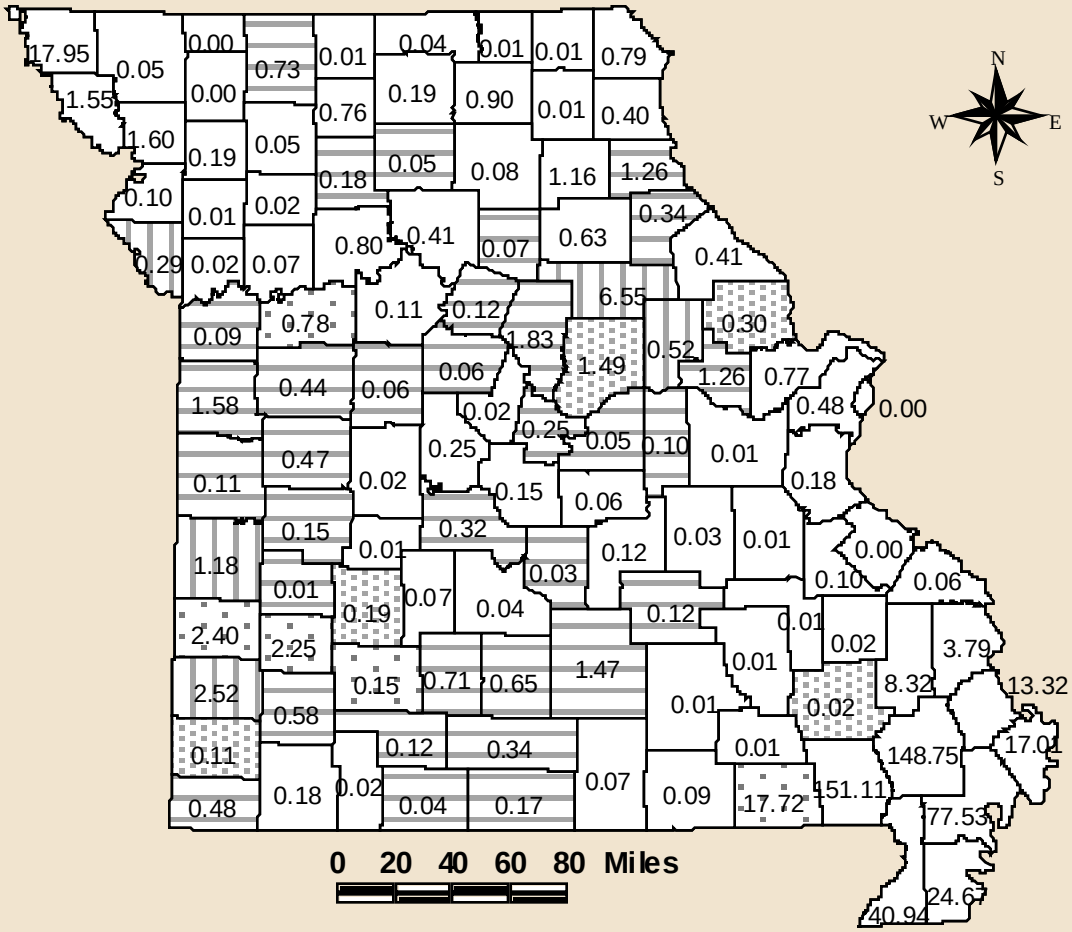
- **no industrial water use**
- **0**
- **80-100**

Number = Industrial water use for that County (Mgal/day)

Source: USGS 1995 Water Use Data for Missouri
http://water.usgs.gov/watuse/spread95.html

SELF-SUPPLIED IRRIGATION WATER USE

See definition - page 53



% of Supply from Surface Water (remainder from groundwater)

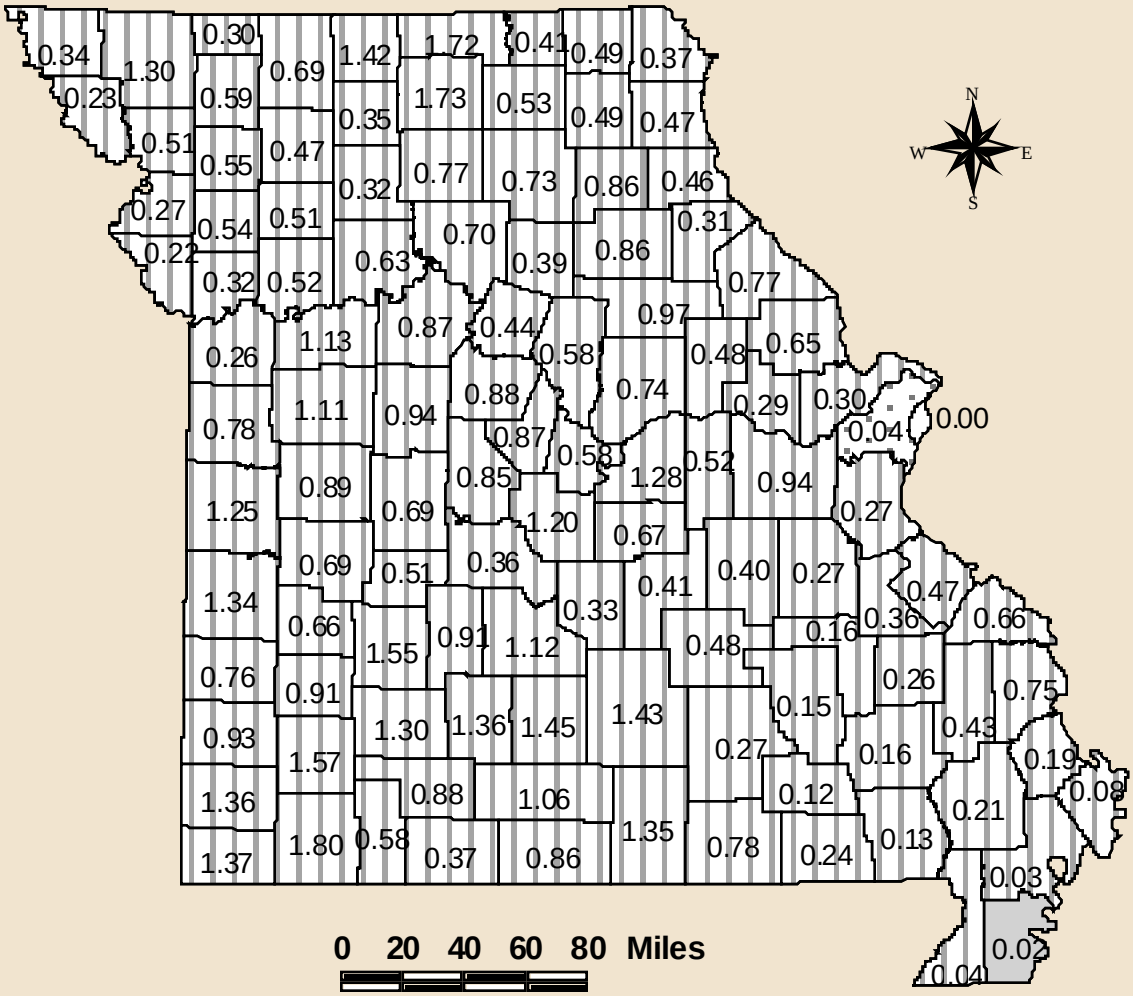
- **0-20**
- **21-40**
- **41-60**
- **61-80**
- **81-100**

Number = Irrigation water use for that county (Mgal/day)

Source: USGS 1995 Water Use data for Missouri
http://water.use.gov/watuse/spread95.html

SELF-SUPPLIED LIVESTOCK WATER USE

See definition - page 53



% of Supply from Surface Water (remainder from groundwater)

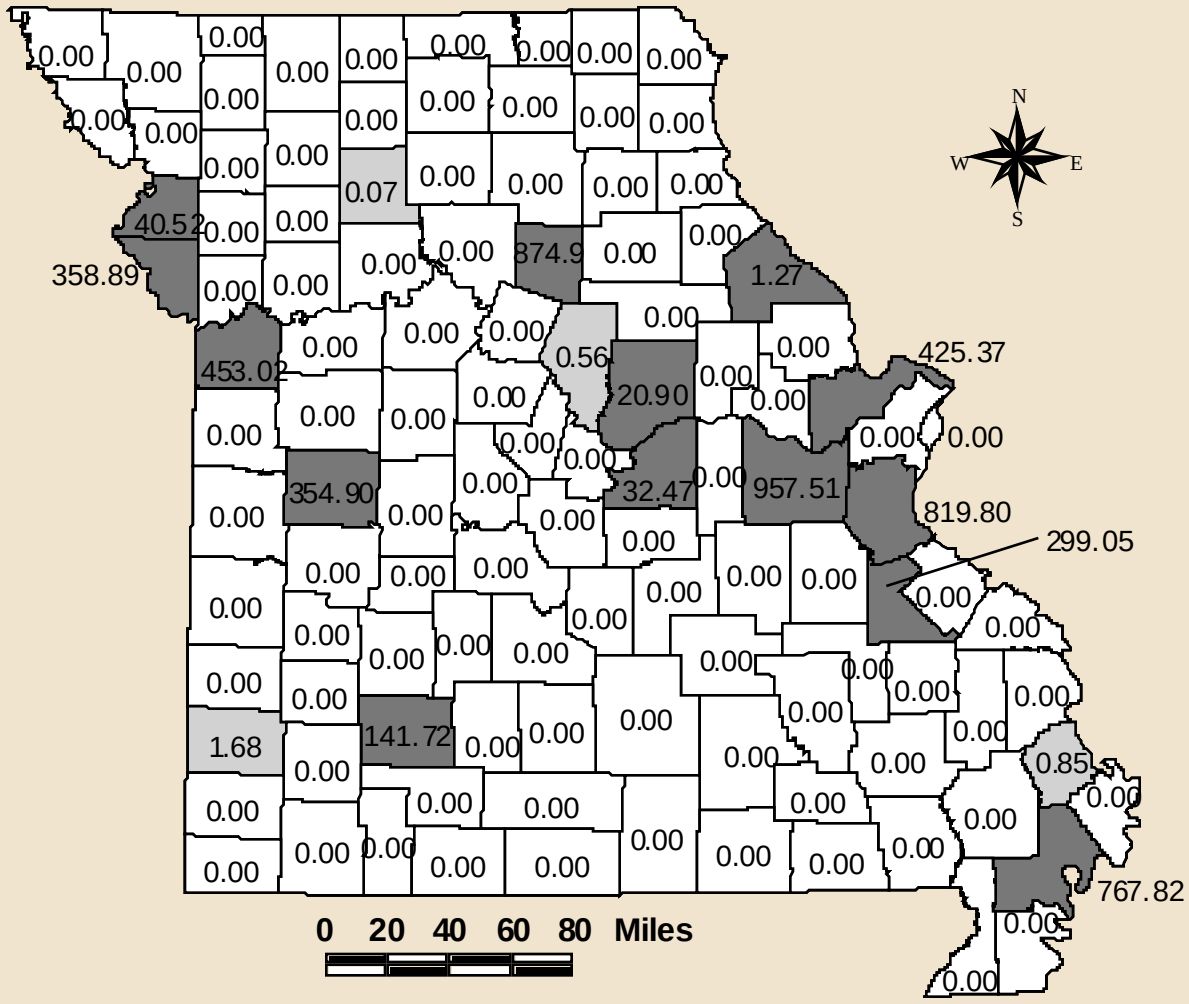
- **0-20**
- **41-60**
- **61-80**
- **81-100**

Number =Livestock water use for that county of (Mgal/day)

Source: USGS 1995 Water Use Data for Missouri
http://water.usgs.gov/watuse/spread95.html

SELF-SUPPLIED THERMOELECTRIC POWER WATER USE

See definition - page 53



% of Supply from Surface Water (remainder from groundwater)

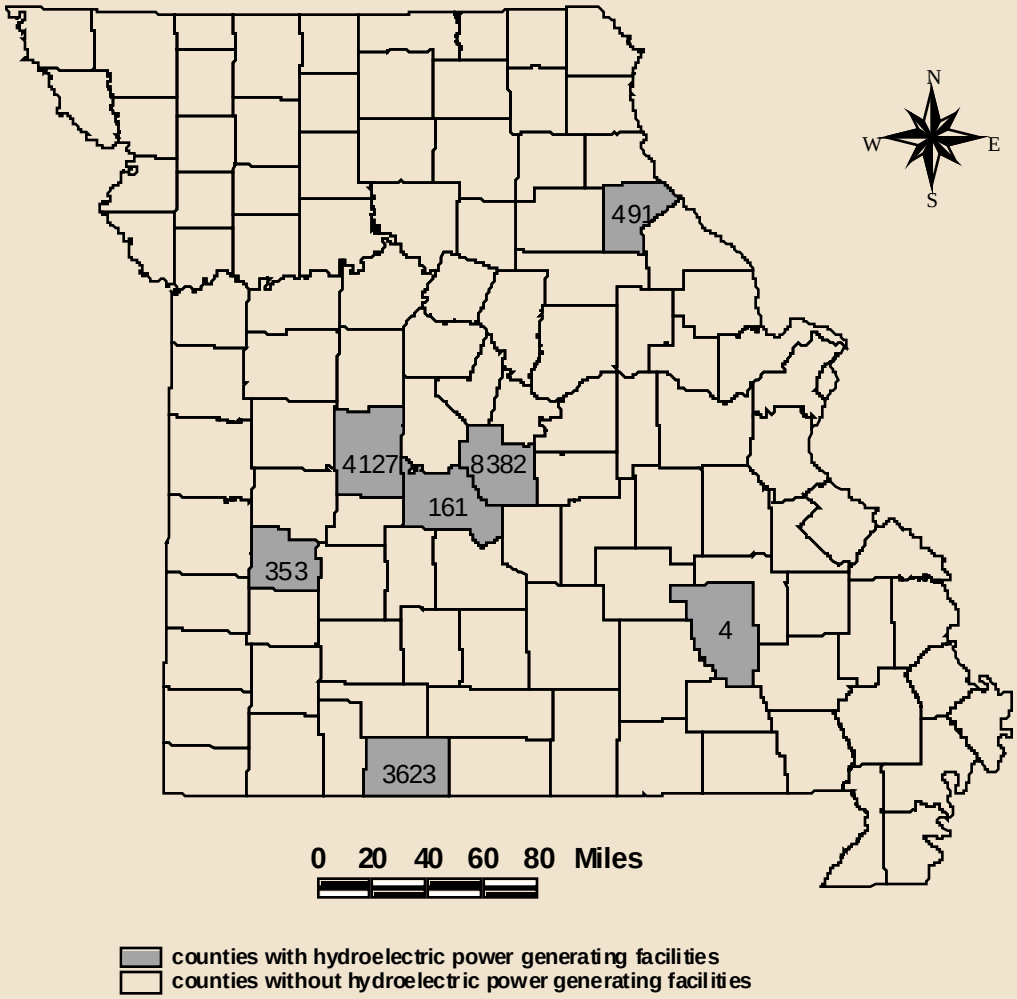
- **no thermoelectric water use**
- **0 (all from groundwater)**
- **95-100**

Number = Thermoeletric water use for that county (Mgal/day)

Source : USGS 1995 Water Use Data for Missouri
http://water.usgs.gov/watuse/spread95.html

SELF-SUPPLIED HYDROELECTRIC POWER WATER USE

See definition - page 53



Number = Hydroelectric power water use for that county (Mgal/d

Source: USGS 1995 Water Use Data for Missouri (http://water.usgs.gov/watuse/spread95.h and Taum Sauk Plant Manager, Ameren UE, personal communication, July 2001.

APPENDIX 13

RESERVOIR FIRM YIELD WATER SUPPLY STUDIES

The use of USDA's Reservoir Operation Study Computer Program (RESOP) can determine a reservoir's capacity to perform in a drought situation. Reservoir operation and management has become an important issue in many areas due to increasing competition for water supplies. The findings from these studies can be used by communities facing drought conditions, or for strategic water planning and drought mitigation, to strike a balance between water supply availability and water use demand.

It is recommended that local communities that perform bathymetric and/or RESOP studies on their own advise the State's Public Drinking Water and Water Resources Program's of their activities and share the findings of their studies so that the data can be added to the appropriate databases. Local communities seeking to perform bathymetric and/or RESOP studies may contact the State's Public Drinking Water and Water Resources Program's for advice and coordination assistance.

One of the results of the Drought Assessment Committee's involvement in the 1999-2000 drought was to more closely examine water systems that can be quickly overtaxed. It is important that local water suppliers know exactly how much water is stored/available or capable of being stored in their local surface water reservoirs. Over time reservoirs can change their bathymetric characteristics (underwater shape and size) due to sediment accumulation. When the capacity of a reservoir is known, any projected or actual short falls can begin to be mitigated and remaining water supplies more effectively managed.

To address the 1999-2000 regional drought problem, the department's Public Drinking Water Program and Water Resources Program collaborated by cost-sharing funds and technical resources with the United States Geological Survey to determine actual reservoir capacities at some surface water reservoirs. These reservoir capacity determinations were accomplished by the use of ship-board global positioning (GPS) and automated sonar depth finder. The bathymetric findings provided base data as to how much water storage was available from the reservoir at specific lake elevations. Engineers and hydrologists then ran the drought-of-record climate patterns against the reservoir's water use demands using the RESOP computer model developed and maintained by the United States Department of Agriculture (USDA).

RESOP utilizes the drought of record as a base line and compares it to current water use demands. The RESOP model uses several variables that include the following:

Lake volume (determined from bathymetry or construction survey calculations) and surface area
Rainfall
Runoff
Lake evaporation
Seepage
Demand or water usage
Other inflow such as pumping from a stream into the reservoir

Sources of data and procedures used to determine remaining storage in water supply reservoirs are:

Reservoir Storage - Reservoirs are surveyed for remaining available storage.

Time Period - The analysis for drought effects is selected to key historical drought event(s) for the area being studied. This typically is the longest and most severe drought of record for the area in which data is available.

Rainfall - Rainfall for each water supply lake is the nearest NOAA weather station. If there were missing days in the data, then the next nearest station is used to fill in the gaps.

Runoff - Regional monthly runoff from nearest stream gages are used. If the rainfall does not look to be reasonable, i.e. runoff greater than rainfall for a certain month, adjustments are made to the runoff by examining each individual rainfall event for that month. To make the runoff determination, five-day rainfall is used to estimate the antecedent moisture. The NRCS cover complex number is used to estimate runoff for each storm.

Evaporation - The nearest NOAA weather station with pan evaporation data is used. Pan evaporation is then adjusted to lake evaporation.

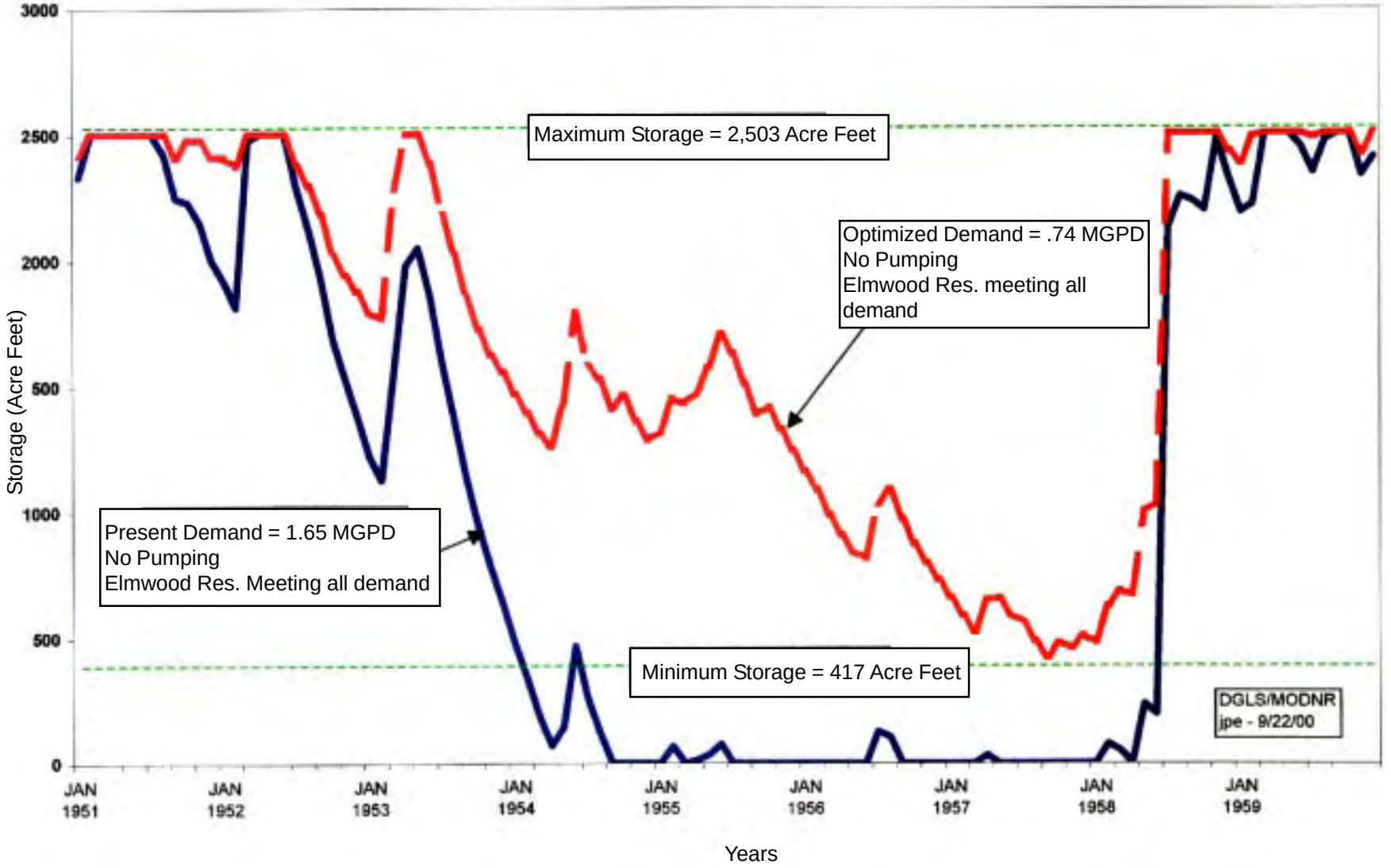
Seepage - Seepage is estimated based on experience. In North Missouri seepage is very low.

Demand - Demand is the amount of water available for consumptive uses. This value comes from community records.

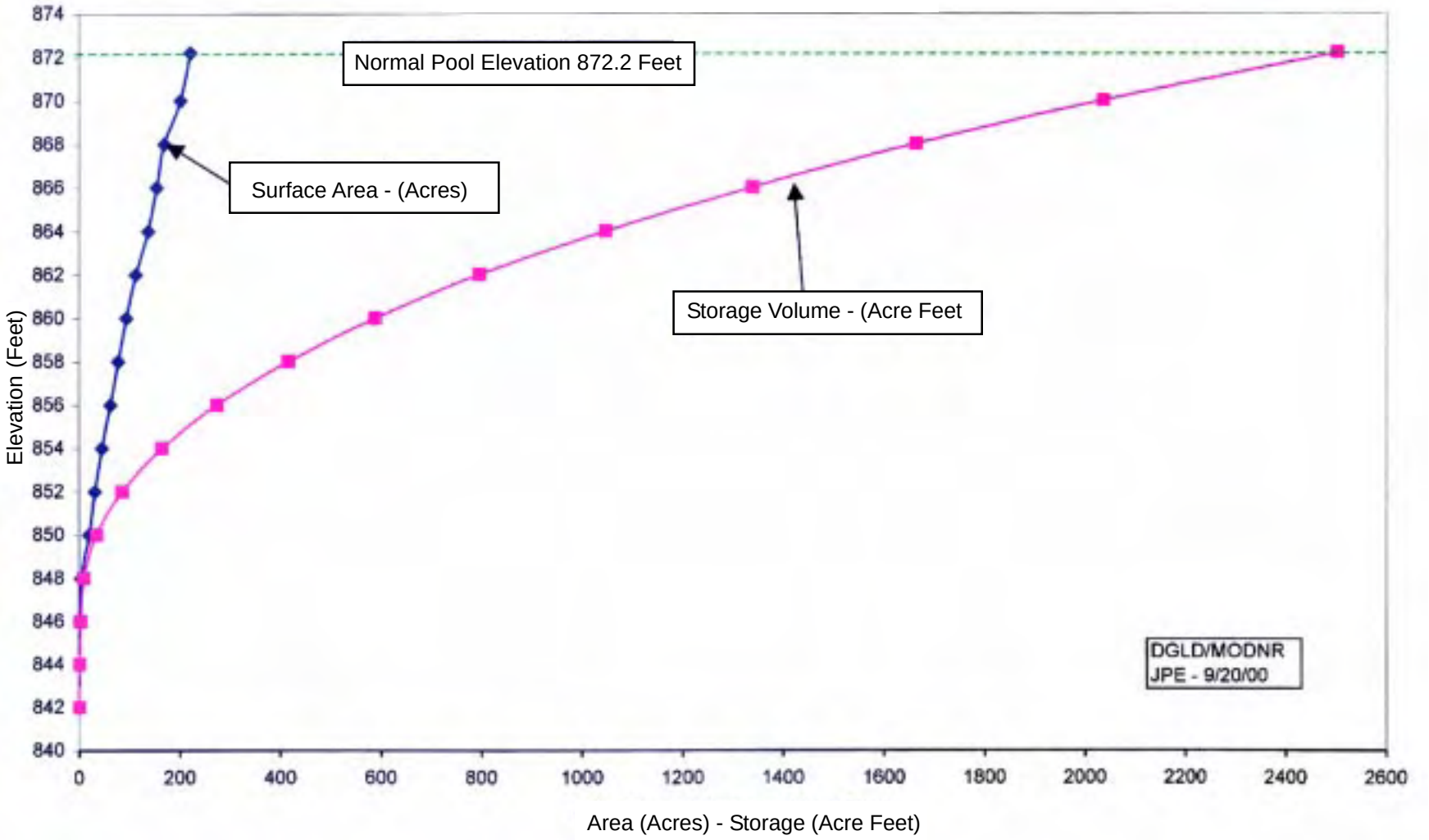
Other - Other is used to identify other inflow or outflow such as pumping from a stream.

The following graphs are two examples of products from the 1999-2000 RESOP analysis of Elmwood Reservoir at Milan, Missouri.

MILAN, MISSOURI
Elmwood Reservoir
Reservoir Operations During the
1950s Drought



MILAN, MISSOURI
Elmwood Reservoir
Storage Based on Reservoir Level



An open file (CD format) report " Water Supply Study, Volume 1" by Edwards and Chen is being developed by the Water Resources Program of the Missouri Department of Natural Resources. The report documents in detail, the studies of the following water supply systems: Milan, Hamilton, Brookfield, Green City, James Port, King City, and the Middle Fork Grand River. The Milan analysis and methodology documentation from that report was used in this Appendix.